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# Final Report

# **ASARCO Tacoma Smelter Remedial Investigation**

Volume 1 — Description of the Current Situation

# **March 1989**

Parametrix, Inc. in Association with Hart Crowser, TRC and ETI and TRC



# ASARCO TACOMA SMELTER REMEDIAL INVESTIGATION FINAL REPORT

**APRIL 1, 1989** 

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# TABLE OF CONTENTS

			Page
1.0		luction	1-1
	1.1	Purpose of Report	1-1
	1.2	Site Background Information	1-1
		1.2.1 Site Description	1-1
		1.2.2 Site History	1-2
		1.2.3 Nature and Extent of Problem(s)	1-3
	1.3	Overview of Report	1-7
2.0	Study	Area Investigations	2-1
	2.1	Surface Features	2-1
	2.2	Air Quality Investigations	2-1
	2.3	Surface Water Investigations	2-2
		2.3.1 Physical Characterization Methods	2-2
		2.3.2 Chemical Characterization Methods	2-3
	2.4	Surface Soil Investigations	2-5
		2.4.1 Soil Sample Locations	2-5
		2.4.2 Soil Sample Collection	2-6
		2.4.3 Analytical Parameters	2-6
		2.4.4 Decontamination of Sampling Equipment	2-8
		2.4.5 Surficial Dust Sampling	2-8
	2.5	Geological Investigations	2-10
	2.6	Groundwater Investigations	2-10
	2.7	Marine Sediment Investigations	2-11
		2.7.1 Surficial Sediment	2-11
		2.7.2 Sediment Cores	
		2.7.3 Biological Investigations	
3.0	Physic	al Characteristics of the Study Area	3-1
J.0	3.1	Surface Features	3-1
	3.2	Air Quality	3-1
	3.3	Surface Water Hydrology	3-1
	5.5	3.3.1 Rainfall	3-1
		3.3.2 Middle Outfall	3-1
		3.3.3 South Outfall	3-1
		3.3.4 North Outfall	3-2
	3.4		3-3
	5.4	Surface Soil	3-3
			3-3
		· 8	3-3
			3-3 3-4
		3.4.4 Off-site Area	J <del>-4</del>

# TABLE OF CONTENTS (continued)

				<u>Page</u>
	3.5	Subsurfa	ce Soil	. 3-4
		3.5.1	Introduction	. 3-4
		3.5.2	Summary of Subsurface Soil Characteristics	. 3-4
		252	and Distribution	
		3.5.3	Plant Area Geologic Units	
		3.5.4	Geologic Units of the Parking Lot Area	
	26	3.5.5	Stratigraphic Units of the Stack Area	
	3.6	3.6.1	vater	
		3.6.2	Introduction	. 3-12
		3.0.2	Summary of Groundwater Flow	. 3-12
		262	Characteristics at the Asarco Site	
		3.6.3	Groundwater Flow within the Plant Area	
		3.6.4	Hydrogeology of the Parking Lot Area	
	27	3.6.5	Hydrogeology of the Stack Area	
	3.7		Sediment	3-32
		3.7.1	Surface Sediment Grain Size	3-32
		3.7.2	Physical Characteristics of Core Samples	3-33
4.0			tent of Contamination	
	4.1		lity	
	4.2		Water	
		4.2.1	Conventional Measurements	
		4.2.2	Metals	
		4.2.3	Organics	
	4.3	Surface S		
		4.3.1	Total Metals Analysis	
		4.3.2	Ep Toxicity (eptox) Test for Metals	4-12
		4.3.3	Base Neutral Organics	4-12
		4.3.4	Acid Extractable Organics	4-13
		4.3.5	Other Analyses	
		4.3.6	Arsenic with Depth	
	4.4	Subsurfa	ce Soil and Slag	4-14
		4.4.1	Summary of Nature and Extent of Contamination in	
			Subsurface Soil and Slag	
		4.4.2	Introduction	
		4.4.3	Inorganics	
		4.4.4	Organics	
	4.5		vater	4-21
		4.5.1	Summary of Nature and Extent of Contamination in	
			Groundwater	
		4.5.2	Introduction	
		4.5.3	Inorganics	
		4.5.4	Organics	4-26

# TABLE OF CONTENTS (continued)

		· <del>-</del>	<u>Page</u>
	4.6	Fill/slag Leaching	4-27
		4.6.1 Summary of Fill Leachate Testing Results	
		4.6.2 Introduction	
		4.6.3 Leaching Test Granular Fill and Slag Sample	
		Descriptions	4-29
		4.6.4 Total Metal and EP Toxicity Procedure Test	
		Results	
		4.6.5 Leachate Water Dissolved Metal Results	4-30
		4.6.6 Comparison of Leaching Test Results to	
		Total and EP Toxicity Results	4-30
		4.6.7 Factors Affecting Slag Leachability	4-32
		4.6.8 Leachability of Granular Fill Versus Slag	
		Fill	4-33
	4.7	Marine Sediment	4-34
		4.7.1 Surficial Sediment	4-34
		4.7.2 Sediment Cores	4-37
		4.7.3 Biological Investigations	4-39
5.0	Cont	aminant Fate and Transport	5-1
٥.0	5.1	Potential Routes of Migration	5-1
	J.1	5.1.1 Summary of Nature of Air Contamination	5-1
		5.1.2 Surface Water	5-3
		5.1.3 Groundwater	5-5
		5.1.4 Groundwater Contaminant Transport	5-6
	5.2	Contaminant Persistence	5-7
	J. <u>_</u>	5.2.1 Presence in Marine Environment	5-7
	5.3	Contaminant Migration	5-20
	<b></b>	5.3.1 Air Quality	5-20
		5.3.2 Surface Water	5-27
		5.3.3 Groundwater	5-29
6.0	Base	line Risk Assessment	6-1
	6.1	Purpose	6-1
	6.2	Indicator Chemicals	6-1
	6.3	Exposure Assessment	6-2
	6.4	Toxicity Assessment	6-2
	6.5	Risk Characterization	6-3
	6.6	Conclusions	6-4
7.0	Summ	nary and Conclusions	7-1
7.0	7.1	Air Quality	7-1 7-1
	/.1	Au Quanty	/-1

# TABLE OF CONTENTS (continued)

			<u>Page</u>
	7.2 7.3 7.4 7.5 7.6	Surface Water	. 7-2 7-2 . 7-3
8.0	Referen	ices	. 8-1
APP	ENDICE	E <b>S</b>	
A B C D E F G	Field Existing Lab T Ground Technol	Dust Sampling Standard Operating Procedures Methods for Geologic and Groundwater Investigations Ing Boring Information Testing Programs for Subsurface Soil Indwater Elevation and Precipitation Graphs Indical Data Summaries Entration Gradient Isopleths for Surficial Soils Samples	

# LIST OF FIGURES

<u>Figure</u>	<u>.</u>	age
1-1. 1-2. 1-3.	Vicinity Map	8 9
10.	Implemented through January 1989	10
2-1.	Wind Rose for Data from 1/1/84 - 12/31/84	23
2-2.	Wind Rose for Data from 1/1/83 - 12/31/83	24
2-3.	Wind Rose for Data frrom 1/1/82 - 12/31/82	25
2-4.	Surface Water Sampling Stations for the Asarco RI	26
2-5. 2-6.	Asarco RI/FS On Shore Surficial Soil and Dust Sampling Locations.  Diagram of Hi-Vol Sampling System Used to Collect Surficial Dust	27
	Samples	28
2-7.	Boring Locations: Current and Previous Studies	29
2-8.	Asarco RI/FS Offshore Surficial Sediment Station Locations	30
2-9.	Marine Reference Station Locations	31
2-10.	Asarco RI/FS Offshore Sediment Core Station Locations	32
2-11.	Benthos Sampling Stations	33
2-12.	Bioassay Stations	34
3-1.	Site Topography Map.	36
3-2.	Hourly Rainfall, Sampling Period and Tidal Movement for the Three Surface Water Monitoring Events	37
3-3.	Hydrographs for the Middle Outfall Catchment Area: Stations SW-1,	
	SW-2, SW-3, SW-4, SW-5, SW-10	38
3-4.	Hydrographs for the South Outfall Catchment Area: Stations SW-1, SW-13, SW-12, SW-11	39
3-5.	Hydrographs for the North and City Outfall Catchment Areas: Stations	ı
	SŴ-6, SŴ-7, SW-8, SW-9	40
3-6.	Site Plan Showing Phase I and II Boring Plus Selected Existing Borings,	
	Site Geographic Areas and Geologic Cross-Sections	41
3-7.	Site Stratigraphic Chart Showing Site Geologic and Hydrogeologic Units	42
3-8.	Generalized Surficial Geologic Map.	
3-9.	Geologic Cross-Section A	44
3-10.	Geologic Cross-Section B	45
3-10.	Geologic Cross-Section C	46
3-12.	Geologic Cross-Section D	47
3-12. 3-13.	Geologic Cross-Section E	48
3-13.	Geologic Cross-Section F	49
3-1 <del>4</del> . 3-15.	Geologic Cross-Section G	50
3-15.	Geologic Cross-Section H	51
3-10.	Fill Thickness Map.	52
~ 1/·	THE ALLEGATIONS INCOME.	2

<u>Figure</u>	<u>Pa</u>	<u>ige</u>
3-18.	Site Plan Showing Phase I and II Boring Plus Selected Existing Borings,	
	Site Geographic Areas and Hydrogeologic Cross Sections	
3-19.	Conceptual Hydrogeologic Cross-Section	54
3-20.	Conceptual Hydrogeologic Cross-Section	55
3-21.	Conceptual Hydrogeologic Cross-Section	56
3-22.	Conceptual Hydrogeologic Cross-Section.	57
3-23.	Continuous Water Level Monitoring: Tidal Influence Study	58
3-24.	Water Table Elevation Contour Map Fill Aquifer, November 10, 1988	۲0
2.05	Low Tide Condition.	59
3-25.	Water Table Elevation Contour Map Fill Aquifer, November 10, 1988 Intermediate Tide Condition	60
3-26.	Water Table Elevation Contour Map Fill Aquifer, November 10, 1988	00
<i>5</i> <b>2</b> 0.	High Tide Condition	61
3-27.	Groundwater Elevations for Parking Lot and Nearby Wells, Glacial Drift	•
J-27.	Sequence and Fill Aquifer November 10, 1988	62
3-28.	Water Level Elevations, Vashon Advance Sand 3 Aquifer, November 10,	٠ <u>ـ</u>
<i>5-</i> 20.	1988	63
3-29.	Water Level Elevations, Vashon Advance 1 Aquifer, November 10,	0.5
5-29.	1988	64
3-30.	Grain Size (% Fines)	65
3-30. 3-31.	Grain Size (% Medium Sand)	66
3-31. 3-32.	Grain Size (% Coarse Sand)	67
3-32. 3-33.	Grain Size (% Gravel)	68
J-33.	Grain Size (% Graver)	UG
4-1.	Total Suspended Solids Concentrations (ppm) in Surface Water	77
4-2.	Antimony Concentrations (ppb) in Surface Water	78
4-3.	Arsenic Concentrations (ppb) in Surface Water	78
4-4.	Cadmium Concentrations (ppb) in Surface Water	79
4-5.	Copper Concentrations (ppb) in Surface Water	79
4-6.	Lead Concentrations (ppb) in Surface Water	80
4-7.		80
4-8.	Nickel Concentrations (ppb) in Surface Water	81
4-9.	Zinc Concentrations (ppb) in Surface Water	81
4-10.	Location of Sampling Stations and Gradient Isopleth Areas	82
4-11.	Total Arsenic Concentration Isopleth in ppm	83
4-12.	Total Arsenic Concentration Isopleth in ppm	84
4-13.	Total Cadmium Concentration Isopleth in ppm	85
4-14.	Total Cadmium Concentration Isopleth in ppm	86
4-15.	Total Lead Concentration Isopleth in ppm	87
4-16.		88
4-17.	Total Copper Concentration Isopleth in ppm	89
4-18.		90

<u>Figure</u>	·· <u>P</u>	age
4-19. 4-20. 4-21.	Total Zinc Concentration Isopleth in ppm	91 92 93
4-22.	Distribution of Total Cadmium Concentration Data in Subsurface Soils	94
4-23.	Distribution of Total Copper Concentration Data in Subsurface Soils.	95
4-24.	Distribution of Total Lead Concentration Data in Subsurface Soils.	96
4-25.	Distribution of Total Mercury Concentration Data in Subsurface Soils.	
4-26.	Distribution of Total Zinc Concentration Data in Subsurface Soils.	98
4-27.	Distribution of EPTox Arsenic Concentration Data in Subsurface Soils.	99
4-28.	Distribution of EPTox Cadmium Concentration Data in Subsurface	100
4-29.	Soils	100
		101
4-30.		102
4-31.	Distribution of EPTox Mercury Concentration Data in Subsurface	103
4-32.		103
4-32. 4-33.		105
4-34.		106
4-35.		107
4-36.		108
4-37.		109
4-38.		110
4-39.		111
4-40.		112
4-41.		113
4-42.		114
4-43.		115
4-44.		116
4-45.		117
4-46.		118
4-47.		119
4-48.	Distribution of Total Chromium Concentration Data in Groundwater.	
4-49.		121
4-50.		122
4-51.		123
4-52.		124
4-53.	Distribution of Total Lead Concentration Data in Groundwater	
4-54.	Distribution of Dissolved Arsenic Concentration Data in	
		126

<u>Figure</u>	<u>P</u>	<u>age</u>
4-55.	Distribution of Dissolved Barium Concentration Data in	
	Groundwater	127
4-56.	Distribution of Dissolved Cadmium Concentration Data in	100
4-57.	Groundwater	
	Groundwater	129
4-58.	Distribution of Dissolved Copper Concentration Data in	
4.50	Groundwater.	130
4-59.	Distribution of Dissolved Lead Concentration Data in Groundwater.	131
4-60.	Distribution of Dissolved Nickel Concentration Data in	122
4-61.	Groundwater	154
4-01.	Groundwater	122
4-62.	Distribution of Dissolved Zinc Concentration Data in Groundwater.	133
4-63.	Total Arsenic, Copper and Zinc Core in Groundwater	
4-64.	Dissolved Arsenic, Copper and Zinc Core in Groundwater	
4-65.	Test Pit Sampling Locations	
4-66.	Dissolved Arsenic Concentrations in Leachate Water	
4-67.	Dissolved Copper Concentrations in Leachate Water	
4-68.	Dissolved Zinc Concentrations in Leachate Water	
4-69.	Arsenic Concentrations (ppm)	
4-70.	Copper Concentrations (ppm)	
4-71.	Lead Concentrations (ppm)	
4-72.	Mercury Concentrations (ppm)	
4-73.	Zinc Concentrations (ppm).	
4-74.	Radium Concentration Isopleths (pCi/g)	
4-75.	Results of Marine Sediment Slag Separation Samples Analyzed for	1.0
,,,,,		147
4-76.	Results of Marine Sediment Slag Separation Samples Analyzed for	
	Copper	148
4-77.	Results of Marine Sediment Slag Separation Samples Analyzed for	
	Lead	149
4-78.	Results of Marine Sediment Slag Separation Samples Analyzed for	
	Mercury.	150
4-79.	Results of Marine Sediment Slag Separation Samples Analyzed for	
		151
4-80.	Marine Sediment Core Analytical Results - Total Arsenic	152
4-81.	Marine Sediment Core Analytical Results - Total Copper	
4-82.	Marine Sediment Core Analytical Results - Total Zinc	154
4-83.	Marine Sediment core Analytical Results - Total Lead	155
4-84.	Marine Sediment Core Metals: EPTox vs. Total	156
4-85	Marine Sediment Core Metals: EPTox vs. Total (continued)	157

<u>Figure</u>	<u> </u>	age
4-86. 4-87. 4-88.	Marine Organism Mean Total Abundances	158 159
	Organism Abundances	160
4-89.	Percent of Oyster Larvae Surviving Standard Error of Each Sample Indicated	161
4-90.	Percent of Oyster Larvae that are Abnormal Standard Error	101
	of Each Sample Indicated	162
4-91.	Amphipod Survival Bioassay.	163
5-1.	Groundwater Mechanisms Associated with Leaching of Contaminated Fill Materials.	30
5-2.	Plant Layout and Source Locations	
5-3.	ISC - 1983 Annual Arsenic Concentrations (in ug/m <sup>3</sup> )	32
5-4.	FDM - 1983 Annual Arsenic Concentrations (in ug/m <sup>3</sup> )	33
5-5.	ISC - Max 8 Hour Arsenic Concentrations (in ug/m <sup>3</sup> )	34
5-6.	ISC - Max 24 Hour Arsenic Concentrations (in ug/m <sup>3</sup> )	35
5-7.	FDM - Max 8 Hour Arsenic Concentrations (in ug/m <sup>3</sup> )	36
5-8. 5-9.	FDM - Max 24 Hour Arsenic Concentrations (in ug/m³)	37 38
5-9. 5-10.	ISC - 1983 Annual Arsenic Deposition (in grams/m <sup>2</sup> ) FDM - 1983 Annual Arsenic Deposition (in ug/m <sup>2</sup> /sec)	39
5-10. 5-11.	ISC - Max 24 Hour Arsenic Deposition (in ug/m³)	40
5-11. 5-12.	FDM - Max 24 Hour Arsenic Deposition (in grams/m <sup>2</sup> )	41

# LIST OF TABLES

<u>Table</u>		Page
2-1. 2-2.	Number of soil samples taken in various Asarco site locations Sediment characteristic codes	
3-1.	Summary of Hydraulic Conductivity (K) Estimate Based on Grain Size Testing.	3-18
3-2.	Summary of hydraulic conductivity (K) estimates based on	
3-3.	laboratory K-testing	
4-1.	Estimated differences in concentrations of inorganic species between different particle sizes at the 95 percent confidence limit.	4-3
4-2.	Marine chronic criteria and ratios of mean outfall concentrations of total metals to criteria	4-5
4-3.	Annual loading estimates of total metals from the three primary outfalls in grams per year	4-5
4-4.	Summary of average metal concentrations in leachate water	
4-5.	Detected EPTox metals	
4-6.	All stations where organic pollutants were above detection limits.	
4-7.	All sediment core samples where organic pollutants were above	
4.0	detection limits.	4-40
4-8.	Dominant taxa and community population parameters for stations.	4-55
4-9.	Immature forms collected at Asarco benthic stations	
4-10. 4-11.	Number of Unidentified Eggs Collected in Benthic Samples Correlations of bioassay results, mean values for	4-48
	all stations	4-52
5-1.	Estimated Average Concentration and Mass Loading for Selected Metals in Groundwater Discharge to Commencement Bay	5-6
5-2.	Contaminant sensitive organisms or interactions	
5-3.	Summary of station properties	
5-4.	Correlation between sediment factors	
5-5.	Particle characteristics used in the modeling	
5-6.	Asarco arsenic concentration and deposition	
5-7.	Annual and 24-hour concentration and deposition at 0.5 km	
5-8.	Ambient monitoring data and model comparison	

#### LIST OF ABBREVIATIONS

cfs cubic feet per second cm centimeters cm/sec centimeters per second f/s feet per second grams  $\bar{\rm g}/{\rm cm}^3$ grams per square meter per year g/L grams per liter g/m<sup>2</sup> grams per square meter g/m<sup>2</sup>/sec grams per square meter per second  $g/m^2/yr$ grams per square meter per year g/yr grams per year gpm/f gallons per minute per foot HPAH high molecular weight polycyclic aromatic hydrocarbons hr  $kg/m^2/yr$ kilograms per square meter per year km kilometer low molecular weight polycyclic aromatic hydrocarbons **LPAH** m/sec meters per second mg/L milligrams per liter mL milliliter millimeter mm PAH polycyclic aromatic hydrocarbons picocuries per gram pCi/g parts per billion ppb parts per million ppm parts per thousand ppt QA quality assurance QC quality control micrograms per gram  $\mu g/g$  $\mu g/m$ micrograms per meter  $\mu g/m^3$ micrograms per cubic meter μm micrometer μmhos/cm micro mhos per centimeter

#### 1.0 INTRODUCTION

#### 1.1 PURPOSE OF REPORT

On September 10, 1986, ASARCO, Inc. (Asarco) and the Environmental Protection Agency (EPA) entered into an Administrative Order on Consent in which Asarco agreed to conduct a Remedial Investigation/Feasibility Study (RI/FS) at its Tacoma Smelter. A total of 14 tasks were identified in the RI/FS work plan that was developed as part of the consent order. Task 6 of the work plan calls for completion of a remedial investigation report.

This Final Remedial Investigation report presents the results of our site characterization work performed during the RI. Since the RI was conducted over a two-year period, an Interim RI report was issued in March of 1988. This document includes the data summarized in the Interim RI report. The characterization studies were designed to determine the nature and extent of contamination, as well as to determine the physical characteristics of the site. The results generated by the RI and presented here will be used to identify those portions of the site that require remedial action.

#### 1.2 SITE BACKGROUND INFORMATION

#### 1.2.1 SITE DESCRIPTION

Task One of the RI/FS work plan is entitled "Description of the Current Situation." This task culminated with the completion of a report that provides a description and history of the site (Parametrix 1987). The following information is summarized from that document.

Asarco, a New Jersey corporation, owns the Tacoma Copper Smelter located in Ruston and Tacoma, Washington. Of the 97+ acres owned by Asarco, the smelter facility occupies approximately 67 acres. The site borders Commencement Bay, the town of Ruston, and nearby urban Tacoma (Figure 1-1). Surrounding land use is primarily suburban residential or recreational (yacht club) with nearby commercial land uses.

During the active life of the Tacoma plant, its primary product was refined copper, which was produced on site until 1979. In March 1985, the smelter was closed due to poor economic conditions for copper smelting and high pollution control costs. The arsenic plant remained in operation through January 1986, at which time the entire facility was shut down. Figure 1-2 is a general layout of the site as it existed when the plant was closed in 1986.

Since January 1987, the site has undergone a stabilization phase. The site stabilization plan called for the demolition of facilities associated with copper smelting and the production of both arsenic trioxide and metallic arsenic. These facilities included electrostatic precipitators, brick flues, the arsenic plant, and miscellaneous structures. Since stabilization began, much of the south part of the site (where these facilities were located) has been leveled and, to a minor extent, graded. Figure 1-3 depicts the site

as it currently exists. Further demolition and stabilization of the site is expected, but at this time its extent is unknown. Due to the likelihood that all structures on the site will be demolished as part of a second phase site stabilization plan, no waste characterization was performed on the buildings that currently remain on-site. However, further demolition will include a classification of the waste left on the site and a determination of how that waste will be handled and disposed.

#### 1.2.2 SITE HISTORY

The following is a chronologic summary of site history:

- 1890 Began operation as a lead smelter.
- 1905 Electrolytic copper refinery and casting facilities completed. Facility purchased by the American Smelting and Refining Company.
- 1913-1917 Plant was rebuilt, stack was constructed, electrostatic precipitators were added.
- 1923 New ore-receiving wharf was constructed.
- 1930 Blast furnace smelting operations were discontinued and replaced with reverberatories that produced slag as one by-product.
- 1950 A sulfuric acid plant began producing acid from the converter off-gases.
- 1960 The sulfuric plant was enlarged.
- 1974 A liquid sulfur dioxide plant began operation, using a dimethylaniline process.
- 1977 A baghouse was installed to handle dust from the arsenic kitchen and metallic arsenic plant.
- 1979 Electrolytic refinery ceased operation.
- 1980-1985 Emission control devices were updated and replaced.
- 1985 Copper smelting operations were discontinued.
- 1986 Arsenic production was discontinued, and facility was taken completely out of production.
- 1987 Site stabilization and demolition activities began.

# 1.2.3 NATURE AND EXTENT OF PROBLEM(S)

As a copper smelter and refinery, the principal contaminants of concern at the site are heavy metals. Specifically, these metals include copper, arsenic, lead, zinc, antimony, mercury, chromium, cadmium, and nickel. Other compounds that may be present on the site include dimethylaniline (DMA), which was used to manufacture liquid sulfur dioxide.

The Commencement Bay Nearshore Tideflats Remedial Investigation (Tetra Tech 1985) identified several organic compounds adjacent to the site (offshore), whose source(s) were not identifiable. These compounds included dibenzofuran, dichlorobenzenes, N-nitrosodiphenylamine, 2-methylphenol, 4-methylphenol, phthalate esters, biphenyl, dibenzothiophene, methylphenanthrenes, retene, methylpyrenes, and 1-methyl(2-methylethyl)benzene. It is possible that historical practices at Asarco could be the source of some of these organic compounds. Therefore, the on-site sampling programs included screening for these compounds.

The extent of the contamination at this time is unknown, and it is one of the objectives of the Asarco RI/FS to determine the contamination's extent. Four basic migratory pathways (or routes of contaminate transport) from the site will affect the extent of contamination. These pathways include transport by subsurface (geologic and hydrogeologic), surface water, atmospheric, and possibly marine environment transport processes. The Task 1 Report: Description of Current Situation (Parametrix 1987) describes these pathways (see Volume 5 - The Task 1 Report). A summary of that document follows:

#### 1.2.3.1 Subsurface Conditions

The available geologic and hydrologic data on and near the project site indicate the potential for surface contamination to migrate to the water table. Water balance estimates indicate that sufficient precipitation falls on the site to allow groundwater recharge, although much of the precipitation falls on paved areas and is collected before infiltration into the subsurface.

Available data indicate that groundwater beneath the Asarco facility flows toward Commencement Bay. This flow occurs within the uppermost saturated geologic units beneath the southern and western portions of the site and within fill materials beneath the portion of the site adjacent to Commencement Bay. Contaminants generally migrate in the direction of groundwater flow. However, vertical migration of contaminants into zones beneath the uppermost geologic units is limited by the relatively low permeability of geologic deposits underlying the site and the upward hydraulic gradients that likely exist beneath these underlying deposits.

Slag and fill leaching may also be a potential subsurface contaminant source. Laboratory tests evaluating the leaching properties of slag were conducted by Crecelius (1986). The results of those tests are summarized as follows:

Arsenic, copper, lead, and silver are leachable from slag.

- After slag has been exposed to flowing seawater for 3-4 months, both the metal leaching rate and toxicity decrease markedly.
- · Cadmium, mercury, nickel, and zinc are not appreciably leachable from slag.
- · Leaching rates decrease after three to four months of exposure to water.
- The slag fill is not a significant source of trace metal loadings to Commencement Bay.

However, no studies have been done to evaluate whether the laboratory results are representative of actual field conditions at the Asarco site.

#### 1.2.3.2 Surface Water Conditions

Surface water runoff pathways for the Asarco RI study area are, in essence, defined by the way stormwater drains off the site. While some minor diffuse surface water runoff occurs near the property boundary with Commencement Bay, the overwhelming majority of surface runoff is channelized or directed to the existing stormwater drainage system. This drainage system has been identified on a general site level by the Tacoma-Pierce County Health Department in its 1983 report for the Washington Department of Ecology (Ecology) (TPCHD 1983). More specific drainage pathways have been identified from Asarco storm drainage blueprints. These drainage conveyances, in most cases, consist of pipes or conduits constructed to transport surface stormwater away from the site. Runoff is generally collected in catch basins, conveyed to the storm drain system, and finally discharged to Commencement Bay through one of three permitted outfalls.

A portion of the on-site surface water drainage is presently being collected and pumped to an evaporator system. This system can retain approximately 60,000 gallons. Water is treated by evaporation using gas-fed submerged burners. Solids settle out to the bottom of the tanks. Waste sludge from this process is dried and then shipped to Asarco's East Helena Lead Smelter for processing.

The integrity of portions of the on-site storm drainage system is in doubt. Drainage flows at the south outfall are always low to non-existent even though a small stream with apparent year-round flow enters the drainage system 150 m (500 ft) from the outfall overflow structure. Such observations suggest that surface waters are entering the groundwater through a break in the on-site storm drainage system. The significance of this leakage is presently unknown.

Because a large portion (50%) of the site consists of impervious substrate (roofs, roadways, and parking lots), permeable surface soils are not present to any large degree. This lack of surface soil has significance in terms of groundwater recharge by surface waters which is, therefore, limited by the impervious surface(s) present.

### 1.2.3.3 Atmospheric Conditions

The Tacoma Smelter has emitted air contaminants since its construction in 1890. The emissions of primary concern have been sulfur dioxide and particulate matter from the 562-ft main stack and various low-level sources, principally the converter-reverberatory building. With the installation of control equipment in the 1970s and 1980s, particulate and sulfur dioxide emissions were substantially reduced.

The following narrative summary of data gives an indication of air quality just before the shutdown, but it does not necessarily reflect current air quality. References to metal concentrations are provided to indicate the potential for continued soil contamination on the site.

Although the only long-term high-volume air sampler near the smelter has never recorded a violation of the ambient (existing) air standard established for total suspended particulate matter, the final decade of smelter operation saw considerable concern over the trace metal contaminants emitted as particulate matter from the smelter. Chemical analysis of stack emissions in 1979 indicated the particulate matter was comprised of 46 percent arsenic, 7 percent lead, and 0.1 percent mercury. Overall, the measurements indicate that the ranking of constituents were (in decreasing order): arsenic, lead, zinc, copper, cadmium, and chromium/mercury (PSAPCA 1980).

Very fine particles are of particular concern because they do not settle out of the atmosphere easily and are carried deeper into the human lung.

Since the smelter shutdown in March 1985 and the subsequent closure of the arsenic plant in January 1986, direct process emissions have stopped. Therefore, the large sulfur dioxide emissions, a major issue during smelter operation, are no longer of concern. However, the potential for continued emissions of particulate matter remains due to clean-up and demolition activity on the site.

Asarco has monitored ambient concentrations of arsenic daily at three locations since 1976. Two of these locations are near the boundary of Asarco's property, within the plant; the other is located 2,100 ft to the southwest. Through 1979, 10 percent of the daily average concentrations exceeded the 2  $\mu$ g/m³ community exposure standard established later by Ecology.

Studies of ambient arsenic concentrations in 1974 and 1977, with and without labor strikes, indicated arsenic concentrations were 12 and 7 times greater during smelter operation than during shutdowns. Average concentrations in the 1977 study were 0.73  $\mu g/m^3$  during operation of the smelter and 0.10  $\mu g/m^3$  during the strike. These concentrations are considerably higher than the 0.002  $\mu g/m^3$  reported by Walsh et al. (1979) for general continental copper smelter sites.

Lead has also been monitored near the smelter at the agency-operated monitoring stations at Ruston School, at N. Baltimore St., and at North 26th and Pearl Streets. Quarterly average lead concentrations have been below the ambient standards since lead

monitoring began in 1978. The lead concentration in particulate matter samples collected by Asarco at its five monitoring sites has been below 1.4  $\mu$ g/m<sup>3</sup> since 1977.

Although the smelter and arsenic plant are no longer operating, on-site cleanup and wind may re-suspend particulate matter from the site and carry it off-site. In fact, a number of studies indicate significant concentrations of contaminants in the soil on- and off-site (Black and Veatch 1988).

Atmospheric transport of particulate matter from the site is a potential pathway for continued contaminant exposure to communities near the plant. Sources include residual process materials, contaminated soil on the site, and dust layers on the surfaces of buildings and other structures. The potential for re-suspension depends on the size distribution and moisture content of the particulate matter, on whether it is aggregated or "glued" to other material, on wind strength, and on other factors.

If the particulate matter from the site is resuspended and carried off-site by winds, people can be exposed by breathing or ingesting particulate matter. Factors affecting the impact of an exposure include the concentration of suspended particulate matter, its chemistry and size distribution, the duration of the exposure, and the sensitivity of the individual or population.

#### 1.2.3.4 Marine Environment

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Possible pathways for migration of contaminants from the Asarco site to the marine environment are currently from groundwater flow and surface water runoff. During plant operation, slag dumping and spills of raw ore from barges during off-loading at the ore dock were also potential migration pathways. However, slag dumping into Commencement Bay ceased January 1, 1973.

Surface water runoff throughout the Asarco site is routed to several outfalls that empty directly into Commencement Bay. Contaminants, primarily heavy metals, come in contact with rainwater and are washed from the smelter site into the marine environment. Upon reaching Commencement Bay, contaminants are dispersed by current and tidal action. The effects of this contamination on the marine environment depends on their concentration and residence time in the discharge area. The outfalls discharging from the site into Commencement Bay have NPDES permits.

Because contaminants can leach from raw copper ore, contamination of Commencement Bay could also have occurred from ore spills during barge off-loading at the unloading docks. Significant ore spills have a greater effect on the marine environment than slag leaching since raw ore has higher concentrations of contaminants than those found in refined slag.

#### 1.3 OVERVIEW OF REPORT

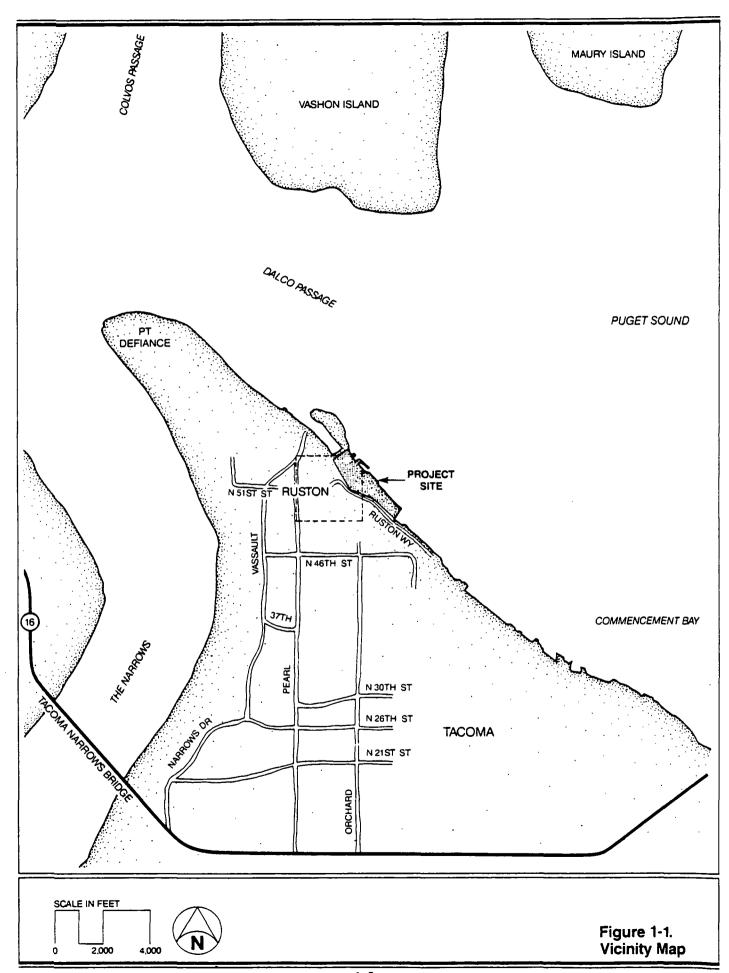
The remedial investigation targeted six media/pathways where the nature of contamination or physical processes were unknown. These six areas included:

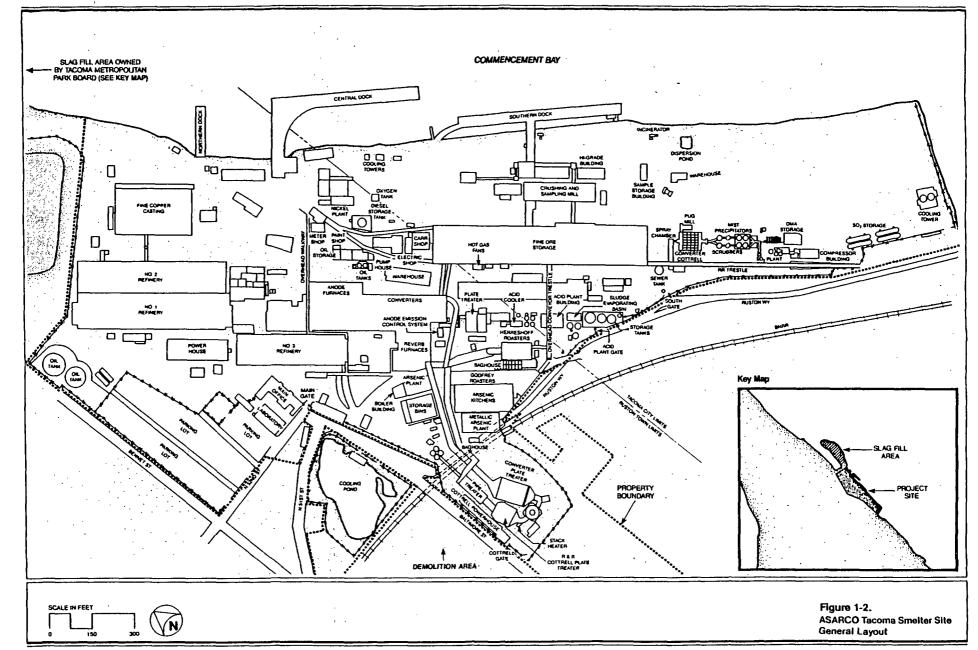
- air quality
- surface water
- surface soil
- geology
- hydrogeology
- marine environment

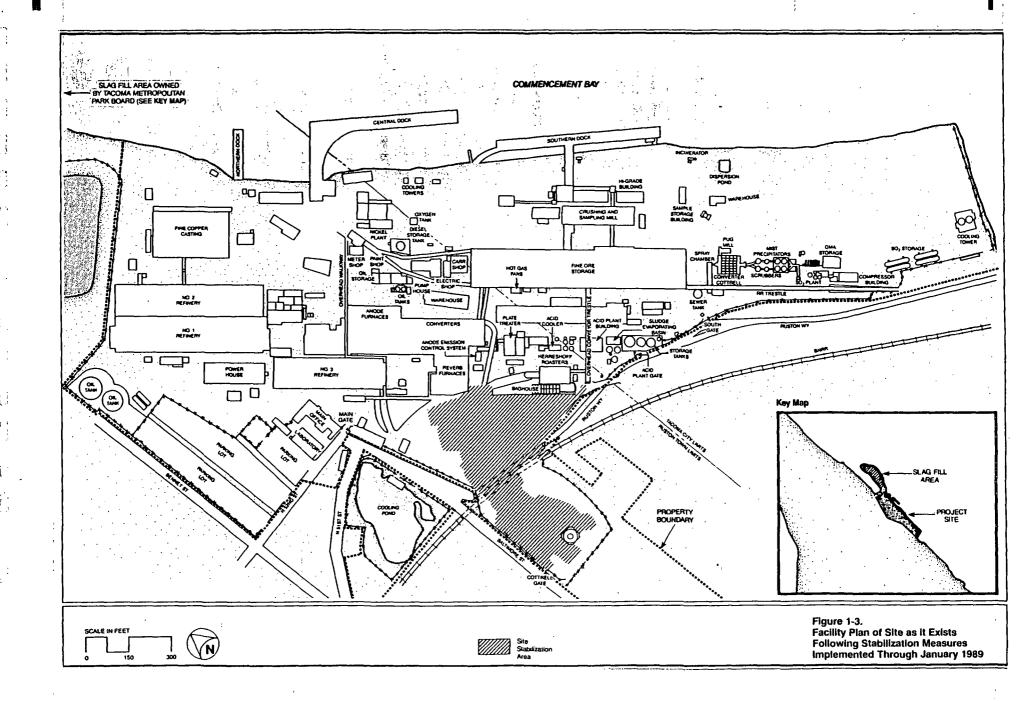
Chapter 2 of the report describes the methods that were used to investigate these areas. Chapter 3 of the report describes the results of the investigations as they pertain to physical site characteristics while Chapter 4 addresses chemical characteristics. Chapter 5 discusses contaminant fate and transport, and routes of migration. A baseline risk assessment (RA) was conducted for the area within the site boundaries and an executive summary of that RA is provided in Chapter 6. The entire RA report is provided separately in Volume 4. Chapter 7 presents the summaries and conclusions of the RI. References cited during this report are provided in Chapter 8.

Figures referenced in the text appear at the end of each chapter where they are referenced. Tables appear immediately following their citation, with the exception of one multi-page table, Table 4-8. Table 4-8 is at the end of Chapter 4.

The complete RI is embodied in four volumes: the technical data are in Volume 2, the data validation report and QA/QC procedures are in Volume 3, and the baseline risk assessment is in Volume 4. Volume 5 is the Task 1 Report: Description of Current Situation.







#### 2.0 STUDY AREA INVESTIGATIONS

#### 2.1 SURFACE FEATURES

The 97-acre site is located on a hillside that slopes down to Commencement Bay. Prominent surface features on the site include a 560-ft stack, car tunnel, railroad tunnel, cooling pond, and several buildings that were associated with the copper smelting process. Some of the buildings located between the stack and lower portion of the site (Figure 1-3) have been demolished. This area has been regraded and all that remains of the structures are the foundations.

An aerial mapping of the site topography and surface features was completed as part of the RI. The photograph was digitized into a computer-aided drafting (CAD) file so that it could be used as a base map and reference tool for alternative evaluations in the Feasibility Study. Also, all sampling stations that were occupied during the RI were surveyed and recorded as state plane coordinates. These locations are included in the CAD file.

# 2.2 AIR QUALITY INVESTIGATIONS

No site specific field investigations were required for the air quality portion of the RI. The air quality investigation uses some of the data gathered from the surficial soil study (Section 2.4) and data from existing meteorological stations installed by PSAPCA and Asarco. The surficial soil data were collected from 22 stations sampled during this RI using a high-vol dust sampler. The methods and approach for these samples are described in Section 2.4.

Asarco routinely collected wind speed and direction data at the Tacoma smelter as part of an operation curtailment program used to control ground-level sulfur dioxide concentrations. Wind data was collected through the end of June 1985 when all liquid sulfur dioxide was removed from the site. The tower was reactivated during site demolition although none of the data was reduced from strip charts. Asarco did not monitor ambient temperature data to determine atmospheric stability or mixing height. However, wind speed and direction data from the Asarco tower is considered the most appropriate data for an air quality analysis of emissions from the Tacoma facility.

SeaTac surface data and Quillayute mixing height data were combined with the Asarco wind data to generate a complete meteorological data set. The Quillayute mixing height data is representative of the marine air mass common to the Puget Sound area. SeaTac airport is within 20 km of the Asarco smelter and is representative of the meteorology of the Tacoma area. The EPA RAMMET meteorological preprocessor was used to create a meteorological input file for modeling analysis.

The Asarco meteorological tower is located at the corner of Baltimore and N. 49th Streets and is called the tavern site. The tower is located on Asarco property approximately 225 m from the Asarco stack. The 18-m tower has a base elevation of 61 m and overlooks the plant. Since the tower is 8 m above the standard meteorological

reference height, wind speeds were adjusted to 10 m using the techniques specified in the EPA document "On-Site Meteorological Program Guidance for Regulatory Modeling Applications," (EPA 1986). Wind speeds were not adjusted below 1.0 m/sec. The data are considered to be the most representative of local conditions at the site. Few hours of wind data for the period 1982 through June 1985 were missing (greater than 90 percent of the data were available) and were substituted with SeaTac data.

Figures 2-1, 2-2, and 2-3 are wind rose representations of the full years (1984, 1983, and 1982) of data used for the Asarco analysis.

#### 2.3 SURFACE WATER INVESTIGATIONS

Surface water investigations were conducted to evaluate the physical and chemical characteristics of runoff entering and leaving the Asarco site. The quantity and quality of surface water was monitored during three rainfall events on January 28, March 22, and June 1, 1988.

Flows were recorded and water samples were collected at thirteen primary surface water (SW) stations (Figure 2-4) every hour of a rainfall event. Samples were collected by three teams of two persons. One team's sampling route was from SW-13 to SW-1 to SW-4 to SW-3. A second team sampled from SW-8 to SW-7 to SW-6 to SW-5. A third team sampled from SW-9 to SW-10 to SW-11 to SW-12. When it stopped raining, the hourly samples were composited into one sample for each station. These samples were composited in proportion to the measured flow at the time of collection, giving a flow-proportional composite sample.

Samples were collected once at the end of each rainfall event from the four secondary stations and five seep stations (SP-1 to SP-5, Figure 2-4). An exception was that seep samples were collected at the beginning of Event 2. And samples were not collected from SP-3 for Event 1 or Event 3 because the seep hole had filled in with soil. Also, two samples of seepage from the car tunnel were collected at SP-6 (Figure 2-4) on December 19, 1988.

The specific physical and chemical characterization methods are described in the following sections.

#### 2.3.1 PHYSICAL CHARACTERIZATION METHODS

Flows were determined every hour at the thirteen primary stations (Figure 2-4). The "bucket and stopwatch" method was used to determine flows at SW-5, SW-8, SW-11, and SW-12. This method involves collecting all of the flow in a graduated bucket for a known length of time to give a flow rate in liters per second. Flows at SW-3 for Event 1 were determined as the difference in flow between SW-4 and SW-2. Flows at SW-3 for Events 2 and 3 were determined by the "bucket and stopwatch" method.

Hourly staff gauge readings were taken at the remaining eight primary stations. Stage-discharge curves were developed for each station using standard hydraulic principles. Flow was determined based on these curves. Weirs were built at these stations as part of the staff gauge flow determinations.

A 90-degree, V-notched weir was used at SW-2, SW-4, and SW-13. A rectangular weir was used at SW-10. A rectangular weir was also used at SW-11 under high flow conditions and low tide. Flows were calculated from velocity measurements at SW-10 and SW-11 when the weirs were inundated with water at high tide. A rectangular weir with a circular orifice was used at SW-6. A circular orifice was used at SW-7. The stage discharge curve for SW-1 was based on pipe flow from a stilling pond that was under inlet control.

Flows at the four secondary stations were measured with the "bucket and stopwatch" method at the time of sample collection during the first and third sampling event:

#### 2.3.2 CHEMICAL CHARACTERIZATION METHODS

# 2.3.2.1 Sample Collection

Two liters of water were collected directly into sample bottles at the primary stations. Four liters of water were collected at the secondary and seep stations. The low water level at SW-5 and the first five seep stations made it necessary to collect water in a decontaminated 1-L beaker and transfer it into the sample bottle(s).

Two samples of car tunnel seepage were collected at SP-6 by catching drops of water directly into a 1-L bottle with a funnel. One sample (Seep A) was taken from a crack located on the north side of the tunnel, about two-fifths of the way into the tunnel from the west end. The other sample (Seep B) was taken from a crack located in the middle of the south side of the tunnel.

Decontaminated 2-L glass bottles were used when samples were to be analyzed for organics. Glass bottles or plastic cubitainers were used when samples were to be analyzed for metals and solids only.

Temperature, pH, and conductivity was recorded at the time of sample collection when the field meters were functioning. All samples were stored on ice prior to compositing and shipment to the laboratory.

# 2.3.2.2 Sample Processing

Samples were processed in Asarco's Tacoma laboratory within 48 hours of collection. Hourly samples from the primary stations were composited into one sample according to flow. A portion of water was taken from each hourly sample in an amount proportional to the flow measurement at that hour to yield a final volume of 3 L. For example, if the flow at the first hour was 10 percent of the sum of flow measurements over the entire sampling event, then a 300 mL volume of the first hour sample was

poured into the composite bottle. Thus, the flow-proportional composite samples were of a quality that was representative of the whole sampling period.

The composite primary samples, secondary samples, and seep samples were inverted several times and poured into bottles provided by the analytical laboratory. Three 1-L glass bottles were filled for organics. A 1-L polyethylene bottle was filled for total metals. A 0.5-L polyethylene bottle was filled for total suspended solids. Each sample was pumped through a 100- $\mu$  glass fiber pre-filter and a 0.45- $\mu$  membrane filter into a 1-L polyethylene bottle for dissolved metals. The samples for metals (both total and dissolved) were then preserved with 0.2 percent ultra-pure nitric acid.

All compositing glassware, filtering equipment and re-used sample composite bottles were decontaminated according to Puget Sound Protocols (Tetra Tech 1986).

A sample from each station for Event 1 was sent to the laboratory for organics analysis. Due to insufficient sample volume, samples from SW-5, SW-10, and SP-3 were not sent for organics analysis. A sample from SW-5, SW-6, SW-10, and SW-11 for Event 2 was sent to the laboratory for organics analysis. A field replicate for organics was sent with the batch of samples for Event 1 only. And a rinsate blank for organics was sent for Event 1 and 2.

A sample from each station for all three events was sent to the laboratory for metals and total suspended solids analysis. SP-3 for Events 1 and 2, and SW-8 for Events 2 and 3, were not sent to the laboratory. This is because soil filled in SP-3, and there wasn't flow at SW-8. Two samples were sent for SW-11 for Events 2 and 3. The last hourly sample for Event 2 and the first two hourly samples for Event 3 contained water that had backed-up the outfall, and they were sent for separate analysis. A field replicate sample and a rinsate blank for metals and total suspended solids were sent for each event.

All samples were packed in insulated containers with blue ice, chain-of-custody forms, and an analysis request list. The analysis request list was as follows:

Metals: Organics:

Antimony Low molecular weight polycyclic aromatic hydrocarbons (LPAH) Arsenic High molecular weight polycyclic aromatic hydrocarbons (HPAH)

Cadmium Dibenzofuran Copper Dichlorobenzenes Lead 2-methylphenol Mercury 4-methylphenol Nickel Phthalate esters

Zinc 1-methyl (2-methylethyl) benzene

Total suspended Biphenyl

solids Dibenzothiophene Methylphenanthrenes

Retene

Methylpyrenes PCBs Dimethylaniline

Conductivity and pH measurements were taken on most samples in the processing laboratory before they were sent to the analytical laboratory. All samples were sent priority air (overnight delivery) to the Asarco laboratory in Salt Lake City, Utah. The organics samples were then sent to Lancaster Laboratories in Lancaster, Pennsylvania.

# 2.3.2.3 Sample Analysis

Laboratory analytical methods are given in Volume 3 - Data Validation Reports.

# 2.4 SURFACE SOIL INVESTIGATIONS

Surface soil, defined as soil to a depth of 12 inches, was sampled to determine the extent of surface soil contamination at the site and to help define its impacts on groundwater and surface water. Surface soil testing also provided data on the availability of contaminated dust-sized particles for wind transport. This data was then used to calculate contaminated fugitive dust emissions from the site.

#### 2.4.1 SOIL SAMPLE LOCATIONS

Soil sampling field activities began October 21, 1987 when sampling stations were located and flagged. Four major areas were identified for soil sampling. These four areas corresponded to smelter activities identified as likely sources of contamination based on historical use:

- Plant Administrative Area
- Cooling Pond
- Site Stabilization Area
- · Off-Site Area

The location of surficial soil sampling sites is shown on Figure 2-5. The actual soil sampling sites were determined by placing a triangular grid over the site. Most of the eastern portion of the site was not sampled for surficial soil because that part of the site is paved and has very limited surface soil exposure.

Soil sampling activities were split into two rounds. Round 1 occurred in October and November of 1987 and was limited to within the site boundaries. The Round 1 soil sampling began on October 27, 1987. Initial sampling was done in the Plant Administrative Area. On October 28, the Cooling Pond Area was sampled, and soil sampling started in the site stabilization area on November 3, 1987. Round 2 occurred in October of 1988 and included some off-site areas and further characterization of the cooling pond area. During Round 2, soil samples were collected from the cooling pond and off-site areas in October 1988.

Because the ore handling and processing areas consist largely of solidified slag or are paved, specialized techniques were used to obtain surficial dust samples. Although such samples are not soil, they do represent the particulate material available for entrainment by the wind. Such samples are necessary to determine levels of hazardous constituents in fugitive dust. Surficial dust samples were collected on November 18 and 19, 1987. Table 2-1 shows the number and type of soil samples taken by site area.

Soil sampling sites were numbered by location and type of sample obtained. Soil samples are identified by the prefix "SS." Soil samples identified with the prefix "SS2" were collected in October 1988 during the second round of sampling. Surficial dust samples are identified by the prefix "NEA." (NEA, Inc. developed the sampling and analytical protocols used for characterizing the level of contamination present in the fine-grained fractions of such samples.) Soil sampling stations were numbered as follows:

• Site Stabilization Area: SS-01 to 50, NEA 5 to 14

• Cooling Pond Area: SS-51 to 60, SS2-01 to SS2-05, NEA 3 and 4

• Administrative Area: SS-61 to 70, NEA 1 and 2

Ore Processing Area: NEA 15 to 22
Off-Site Areas: SS2-06 to SS2-27

Stations SS-05, SS-07, SS-14, SS-15, SS-17, SS-18 could not be sampled. They are located atop the foundations of the arsenic kitchens and the Godfrey Roaster buildings.

A total of 99 surficial soils samples were collected and 30 dust samples were collected.

#### 2.4.2 SOIL SAMPLE COLLECTION

Soil samples were obtained using a 3-inch-diameter stainless steel hand auger. Surficial materials (such as slag crusts or organics such as grass) were carefully removed. The soil, which consisted of mixed sands and gravels at all locations, was sampled using the hand auger. Two to 5 penetrations with the auger were required to extract enough soil for sample preparation. Soil samples were deposited into a stainless steel bowl. The bowl was shaken by hand to separate the gravel from the lighter soil. After removal of the gravel, the soil was homogenized thoroughly, separated into quarters, and an aliquot from each quarter placed into a sampling container. All samples were obtained in this manner except for two soil sampling stations: SS-61 and SS-62. Because large rock fragments and pieces of slag at these two stations precluded using a hand auger, the soil samples were collected with a stainless steel trowel.

#### 2.4.3 ANALYTICAL PARAMETERS

Surficial soil samples collected during the first round of sampling in October and November 1987 were analyzed for hazardous substance list (HSL) semi-volatile organics (Acid and Base Neutral Extractables), total metals and Extraction Procedure Toxicity (EPTox) metals. Surficial soil samples collected during the second round of sampling in October 1988 were analyzed for total metals, EPTox metals, arsenic at the surface, and arsenic only at three depths: 3 to 4 inches, 6 to 7 inches, 11 to 12 inches.

Table 2-1. Number of soil samples taken in various Asarco site locations.

<del></del>	Sampling Location					
Type of Sample	Plant Administrative Area	Cooling Pond	Site Stabilization Area	Ore Handling and Processing	Off-site Area	
Soil	10	15	44	0	20	
Surficial Dust	2	2	10	8	-0	
Q.A. One set, sampling containers	0	0	1	0	0	
Field Blank, rinsate	0	0	1	0	- 0-	
Duplicate	. 1	2	2	0	1	

The laboratory analytical protocol and QA/QC procedures are presented in Volume 3. The list of compounds/elements analyzed for in the Round 1 and 2 samples follows:

#### Total Metals - Round 1

Arsenic, Cadmium, Chromium, Lead, Antimony, Mercury, Copper, Zinc, Nickel, Silver, Selenium, Thallium, Barium, Uranium

#### Total Metals - Round 2

Arsenic, Cadmium, Chromium, Lead, Antimony, Mercury, Copper, Zinc, Nickel

#### EPTox Test - Round 1

Metals: Arsenic, Chromium, Mercury, Silver, Cadmium, Lead, Selenium, Barium

### EPTox Test - Round 2

Metals: Arsenic, Barium, Cadmium, Chromium, Copper, Lead, Mercury, Selenium, Silver, Zinc

# Base Neutral Organics - Round 1

Dibenzofuran, Dichlorobenzene, Phthalate esters, low and high molecular weight polycyclic aromatic hydrocarbons (LPAH and HPAH)

#### Acid Extractable Organics - Round 1

2-methylphenol, 4-methylphenol, dibenzothiophene, methylphenanthrenes, 1-methyl (2-methylethyl) benzene, biphenyls

#### Other Analytes - Round 1

dimethylaniline, uranium, radium-226, gross alpha, pH, PCBs

# Arsenic with Depth - Round 2

Arsenic analyzed at depths of 3 to 4 inches, 6 to 7 inches, 11 to 12 inches

### 2.4.4 DECONTAMINATION OF SAMPLING EQUIPMENT

Sampling equipment was decontaminated between collection of each sample. The decontamination procedure consisted of:

- · tap water and alconox wash
- distilled water rinse
- acetone rinse (using ACS grade acetone)
- methanol rinse (using ACS grade methanol)
- · distilled water rinse
- air dry

As further precaution, field team members wore gloves.

Samples were placed in sample containers provided by the laboratory. Individual containers were labeled and placed in insulated shipping containers with frozen artificial ice packs. Shipping containers were sent daily by air courier to the laboratory.

The samples were listed on the Sample Tracking Report. A chain-of-custody form was filled out, one copy retained by the field team and two forwarded with the samples to the laboratory. Field documentation, including chain-of-custody, sample tracking reports, courier receipts and sample shipment air bills was done according to the project data management plan.

#### 2.4.5 SURFICIAL DUST SAMPLING

A total of 22 surficial dust samples was collected. The location of these sampling points is shown on Figure 2-5. Individual locations are designated by the prefix "NEA." The surficial dust sampling locations were selected by placing a triangular grid over the entire

site and using a random number generator to select positions on the grid. All sampling locations selected randomly were sampled if there was any dust to be sampled. Some locations had to be shifted somewhat to accommodate where the dust was.

Samples were obtained using a "Hi-Vol" sampling system specifically configured for this task by NEA, Inc., 10950 S.W. 5th Street, Beaverton, Oregon 97005. The device consists of a motor driven air pump, a filter mounting device, a filter and an orifice. As air is drawn through the orifice, fine-grained particles carried along by the air flow are trapped on the filter. A diagram of the technique is shown in Figure 2-6. This technique allows for collection of enough sample volume for inorganic contaminant analysis by size fraction to be used in air quality dispersion modeling of fugitive dusts.

At each sampling site, 10 sq ft of surface area was vacuumed by this device. The objective was to obtain a representative sample of the surface dust present. Five sections located in a 10- to 20-ft radius around the sample point were sampled. Each section was 2 sq ft. The five samples taken radially were obtained on the same filter, which resulted in a single composited sample for each site.

All samples were obtained using procedures and protocols provided by NEA. These standard operating procedures are contained in Appendix A - Road Dust-Sampling-Samples were analyzed at the NEA Laboratory for 34 elements by X-ray fluorescent (XRF). The elements analyzed by XRF were:

Aluminum Selenium Silicon Bromine Phosphorus Rubidium Sulfur Strontium Chlorine Yttrium Potassium Zirconium Calcium Molybdenum Titanium Palladium Vanadium Silver Chromium Cadmium Manganese Indium Iron Tin Nickel Antimony Copper Barium Zinc Lanthanum Gallium Mercury Arsenic Lead

Area descriptions, station identification, date, time, and other pertinent information were logged according to the Project Data Management Plan.

Filter and dust samples obtained by this method were contained in appropriately-sized ziplock bags and then placed in 7-by-10-inch manila envelopes. Manila envelopes were, in turn, shipped to the NEA laboratory for analysis on a daily basis.

#### 2.5 GEOLOGICAL INVESTIGATIONS

The objective of the geologic investigation was to characterize the nature and distribution of subsurface soils beneath the site. This geologic assessment forms the physical framework to assess potential subsurface soil and groundwater contaminant migration pathways and receptors.

Site geology and stratigraphy were evaluated by conducting site reconnaissance of surface geology, review of previous borings, and drilling exploratory boreholes to evaluate subsurface conditions. Borings at 13 locations, designated MW-1 through MW-13, were completed for Phase I in September and October 1987. Borings at 24 locations, designated B-14 through B-37, were completed for Phase 2 in August and September 1988. At some locations multiple borings were required; they were designated MW-2A, MW-2B, and so forth. The locations of these explorations are shown on Figure 2-7.

Detailed descriptions of the exploration and soil sampling methods are given in Appendix B - Field Methods for Geology and Groundwater Investigations. Appendix B also includes boring logs for each of the borings. The logs of previous borings reviewed are included for reference in Appendix C - Existing Boring Information.

Selected soil samples were taken to the laboratory for grain size and hydraulic conductivity testing. Detailed descriptions of the test methods and the results are given in Appendix D - Laboratory Testing Program for Subsurface Soils.

#### 2.6 GROUNDWATER INVESTIGATIONS

The objectives of the groundwater investigation was to describe the groundwater flow characteristics and groundwater quality beneath the site. The groundwater flow and quality characteristics form the basis for assessing potential contaminant migration, identifying potential receptors, and for estimating contaminant loadings to the receptors.

Observation and monitoring wells were installed in all borings except for B-1A, B-2C, B-2C2, B-3A, MW-5, B-7, B-10, B-15, B-23, B-24, and B-25. Detailed descriptions of the installation methods, well development, groundwater sampling, and groundwater level measurements are given in Appendix B - Field Methods for Geology and Groundwater Investigations. The boring logs in Appendix B also show the depth of each well screen and the details of the well installation. The results of the groundwater level measurements are also presented in Appendix B.

The horizontal hydraulic conductivity of subsurface soil was determined with in-situ hydraulic conductivity tests (slug tests) on selected wells. Detailed descriptions of the method used and the results are presented in Appendix B.

### 2.7 MARINE SEDIMENT INVESTIGATIONS

The remedial investigation of the aquatic environment near the Asarco Tacoma Smelter was designed to investigate the following: (1) distribution of any surficial sediment contamination; (2) depth of sediment contamination; and (3) biological impacts of sediment contamination.

### 2.7.1 SURFICIAL SEDIMENT

Surficial sediments are defined as the top 2 cm of sediment on the sea bottom. The objectives of the surficial marine sediment investigation were the following:

- · to determine the areal distribution of any surficial sediment contamination
- to provide a map of contaminated areas (isopleths) and contamination gradients near the smelter
- to select benthic and bioassay sampling stations in areas not significantly contaminated, significantly contaminated, and severely contaminated by toxicants.

In October and November 1987, 96 stations were sampled for surficial sediment chemistry. In July 1988, seven additional stations were sampled and 19 of the original stations were revisited. Station locations are shown in Figures 2-8 and 2-9. Previous studies have identified an area where contaminants have been found that may have originated on the Asarco site. This area extends from the shoreline to a depth of approximately 200 ft mean lower low water (MLLW), and from north of the Tacoma Yacht Club to well south of the smelter. The distance between sampling stations is smallest near the copper and ore docks, the area with the highest probability of contamination, and greatest at the north and south ends of the study area. This distribution is based on the data from the Commencement Bay Nearshore Tideflats Remedial Investigation (Tetra Tech 1985).

# 2.7.1.1 Sample Collection

Positioning of the sampling vessel used a land-based electronic distance measuring (EDM) system. The accuracy of this system is 1.5 to 3.0 cm, which is much more accurate than a vessel can hold steady on station. The Puget Sound Protocols (Tetra Tech 1986) have recommended an accuracy of  $\pm 2m$  for surficial sediment sampling. A prism reflecting board was fixed to the sampling vessel for operation of the EDM system. Position calculations were compensated for the offset distance from the reflecting board to the sampler wire in order to place the wire at the station location rather than the reflecting board. The sampling vessel was held into the current during strong tides while the sampler was being deployed. Station location readings were also given to the helmsman as the sampler was being deployed as an additional effort to stay on station. In June and July of 1988 the additional surficial sediment samples were taken using a Motorola Mini Ranger positioning system calibrated by EDM, which was accurate to within 1 m. These highly accurate station location techniques allow for more closely

spaced stations and, therefore, better detection of contamination trends or gradients and repeatability for future sampling if needed.

Collection procedures followed the Puget Sound Protocols (Tetra Tech 1986). Surficial sediment samples were collected using a modified  $0.1\text{m}^2$  van Veen grab and in 1988 a modified  $0.1\text{m}^2$  double van Veen grab. The grab was lowered and raised at a controlled speed of approximately 1 ft/sec. After the sampler was lowered, raised, and secured on deck, the sediment sample was inspected carefully before being accepted. The following acceptability criteria were used:

- the sampler is not over-filled with sample so that the sediment surface is pressed against the top of the sampler
- overlying water is present (indicates minimal leakage)
- the overlying water is not excessively turbid (indicates minimal sample disturbance)
- the sediment surface is relatively flat (indicates minimal disturbance or winnowing)
- the desired penetration depth is achieved (that is, 4-5 cm for a 2-cm deep surficial sample).

Any sample not meeting these criteria was rejected. After a sample was judged acceptable, sediment characteristics were recorded using a 5-character sediment type code (Table 2-2). Station location, water depth, grab penetration depth, and other general observations were also recorded on field data sheets. Sample numbers assigned to each sample included a code system identifying the type of sample collected and the location sampled.

Before sampling surface sediment, overlying water was removed from the grab by slowly syphoning the water off near one side of the sampler. Minimal sediment surface disturbance is desired before taking a sample. Once the overlying water was removed, the top 2 cm of sediment was sampled using a stainless steel spoon. Extreme caution was taken to avoid contamination of the surface layer from contact with the sides of the sampler and other sampling equipment. Sediment was placed in a large stainless steel mixing bowl which had been washed with acetone then rinsed in deionized water. Then, the sediments were homogenized before placement into appropriate sample jars. Organics and grain size samples were placed in glass jars, while metals, radium, and EPTox samples went into plastic jars. All jars carried appropriate exterior labels and were placed on ice (4°C) in coolers.

Because it was impossible to sample the very hard substrate of transects T0, T1, and T2 with the grab sampler, SCUBA divers were used to obtain samples at Stations T0-2, T0-3, T1-1, and T2-1. Because the actual T0-3 was located too deep for divers to sample, the site sampled was about 100 m shoreward along the transect (water depth approximately 60 ft). The divers collected the top 2 cm of sediment with a shallow stainless steel spoon and placed it in a stainless steel bowl underwater, covered the bowl

Table 2-2. Sediment characteristic codes.

Station:

Number Specific for this Project

Sequence No:

Specific for this Project

Depth:

Depth of Sediment in Center of Grab or in Core

Sample Type:

B-Biological, C-Chemical, M-Metals, V-Volatile, G-Grain Size

Sediment Type (Principal/Secondary):

6 = Clay

5 = Silt

4 = Sand

3 = Gravel

2 = Cobble

1 = Boulder

Sample Debris:

7 = Wood Chips

C = Coarse Sand

F = Fine Sand

M = Medium

Sediment Color:

B = Black

BWN = Brown

GY = Grey

G = Green

DO = Drab Olive

Sediment Odor:

 $1 = H_2S Smell$ 

A = Slight Odor

2 = Petroleum Smell

B = Moderate Odor

3 = No Smell

C = Strong Odor

D = Overwhelming Odor

Use a slash between color and odor codes to indicate differences between layers in the sediment.

so that the cover did not touch the sediments, and returned the bowl to the boat. These sediments were processed exactly as those taken from the grab sampler, including washing the bowl and spoon with acetone and deionized water between samples. Surficial sediment samples collected for organic, metal, radium (1987), and EPTox (1988) analyses were transported from the field to the Asarco Tacoma Smelter main office. Chain-of-custody forms were prepared listing every sample being transported and the type of analyses that the samples were to undergo. Samples were then packaged in coolers with cold packs and shipped daily to the Asarco Salt Lake City, Utah laboratory. No samples were sent on Fridays, because weekend delivery could not be guaranteed. Copies of the chain-of-custody records accompanied the shipped samples to be signed and returned to Parametrix with analyses results.

Grain size analysis followed the protocol outlined in pages 30-41 of Methods for the Study of Marine Benthos, International Biological Programme Handbook No. 16 (Holme and McIntyre 1971). This method has been accepted by the Washington Department of Ecology for analysis of grain size samples collected in Puget Sound. Silt and clay fractions are separated using pipette analysis. Coarse material is broken down into a gravel fraction (>2 mm) and five sand fractions (1 mm, 0.5 mm, 0.25 mm, 0.125 mm, 0.063 mm). Quality control was conducted on every sample. Each sample must show a recovery of 95 to 101 percent of original material to pass the QC test. Samples that failed the QC test were re-analyzed until a passing recovery was obtained.

Sediment samples were analyzed for the metals arsenic (As), copper (Cu), lead (Pb), and zinc (Zn) by the Asarco laboratory and for the organics LPAH, HPAH and dibenzofuran by an Asarco subcontractor laboratory for the original 96 samples in 1987. In addition, 10 of the 96 samples were analyzed for radium. In the 1988 samples for metals, mercury (Hg) was also included along with an EPTox analysis, and the organics analyses (Lancaster Labs 1988) included Pesticide/PCB analysis and TOC. Analytical protocol and QA/QC procedures used in these analysis is described in Volume 3 - Data Validation Report.

# 2.7.1.2 Slag Particle Separation Analysis

An experiment was conducted on four marine sediment samples (T4-1, T4-2, T14-2 and T15-2 - Figure 2-8) to determine what the chemical concentrations were for various particle types present in the sample. The purpose of the experiment was to try and separate the slag particles from the native sediment and analyze the two types separately for chemical concentration.

Grab samples were collected using a van Veen grab following those methods described previously. Multiple samples were required from each station because a large volume was necessary to test the various sediment types for the chemical analyses. Grab samples were homogenized in a stainless steel bowl and transferred to glass jars for shipment to the laboratory. Three jars per station were filled. One of the jars was sent directly to the analytical lab (Asarco Salt Lake City) for chemisty testing, and the other two were shipped to Parametix' lab for particle type separation.

Particle type separation required drying and sieving the sample. Due to the concern over how sample handling (drying and sieving) may affect its chemical characteristics, a sample was dried, fractioned, and recombined to serve as a control. The recombined sample involved taking the contents of one jar, drying it, passing it through a series of five sieves (2.0, 1.0, 0.5, 0.25, and 0.063 mm), recombining it, and then placing it back into the jar for shipment to the Asarco lab.

The second jar returned to the Parametrix lab was used for particle type separation. The contents of the jar were dried and passed through the same 5-sieve series mentioned above. All sieves were decontaminated between sample processing.

The purpose of sieving the sample was to provide a "first-cut" at slag particle separation. The slag particles tended to be larger and were more easily removed if the sample was first sieved into different size fractions.

Although slag was the most dominant type in the large size fractions (material retained on the 2.0 and 1.0 mm sieves), slag and native sediment were present in all size fractions. And it was not practical to remove the slag particles from the smaller size fractions. They appeared as small black slivers and were distinguishable from the browngray color of the native material, but were too small to be easily removed. Therefore, slag particle separation did not actually occur for all the size fractions. For the large fractions (2.0 and 1.0 mm), the small amount of native sediment was removed. This native sediment was easily distinguishable, in very small quantities, and in particle sizes large enough to easily handle.

In actuality, samples were separated by size fraction not particle type. Three size categories were created for each sample, a large, medium and small. The large category tended to be predominantly slag, the medium category a mixture of about equal parts native material and slag, and the small category predominantly native material with very little slag. The sieve sizes that made up these categories were these: large (2.0 and 1.0 mm), medium (0.25 and 0.063 mm), and small (less than 0.063 mm). The material retained on the 0.5 mm sieve was not used for chemical testing. It varied from sample to sample as to whether it was mostly slag, mostly native, or about 50-50 and therefore did not fit well into the categories established for slag particle separation.

In summary, for each station sampled in the field, five samples were sent to the lab for chemistry analysis. The samples were analyzed for the following total metals: arsenic, copper, lead, zinc, and mercury. The five chemistry samples submitted from each station were categorized as follows:

1) Field Sample: sent directly from the field

2) Recombined Sample: dried, sieved, recombined, and sent

3) Large Particle Size: dried, sieved, and material retained on 2.0 and 1.0 mm sieves sent after removal of most native sediment

4) Medium Particle Size: dried, sieved, and material retained on 0.25 and 0.063 mm sieves sent

5) Small Particle Size: dried, sieved, and material passing through 0.063 mm sieve sent

#### 2.7.2 SEDIMENT CORES

Marine sediment core sampling was designed to examine the vertical extent of sediment contamination. Core sampling stations were selected from those stations already sampled for surficial sediment chemistry. The selections were based on chemistry data from the surficial sediment samples and sediment cores collected for the Commencement Bay Nearshore Tideflats Remedial Investigation (Tetra Tech 1985).

Marine sediment core samples were collected with a barge-mounted drill rig in November and December 1988 and analyzed for metals and organic contaminants. The barge was positioned on sampling stations using a land-based electronic distance measuring (EDM) system and visual sight lines. Samples were collected with two types of modified Dames and Moore Type U Samplers and separated into decimeter depth increments. Each depth increment was examined and physical characteristics were described in the field notes. The upper 5 dm and the deepest core section from each station were shipped to laboratories and analyzed for arsenic, copper, lead, zinc, LPAH, HPAH, and microtox toxicity. The analytical protocol and QA/QC procedures for these analyses are provided in Volume 3.

# 2.7.2.1 Station Positioning

The barge-mounted drill rig used to collect core samples was positioned on sampling stations using buoys and visual site lines so that surveyors were not needed throughout the sampling effort. An anchor attached to a line with a small torpedo buoy was dropped from a boat at each station. The stations were located with a shore-based EDM system having an achievable accuracy of 1.5 to 3.0 cm (Tetra Tech 1986). Deflection of the anchor by currents as it descended through the water probably introduced some error in the buoy positioning.

Visual site lines were established at the time of buoy placement to ensure accurate barge positioning. Puget Sound Estuary Program (PSEP) Protocols (Tetra Tech 1986) state that optical positioning can be highly accurate within 0.5 km of shore and may be preferable along the waterfront of urban areas. Two easily distinguished fixed objects that were in alignment on shore were described in the field notebook. A second set of objects in alignment at approximately a right angle to the first sight line were also noted. This enabled us to return to the station and place the drill rig at the intersection of the two visual axes. The combination of EDM and visual site line positioning allowed for core samples to be collected within the probable area sampled during surficial sediment sampling. The barge was repositioned offshore up to 40 ft at several stations to avoid slag cobbles and large rocks that the core sampler could not penetrate.

# 2.7.2.2 Sampling Equipment

Marine sediment core samples were collected from a 20-by-34-ft barge equipped with a hollow-stem auger drill rig. The barge and drill rig were operated by Tom Campbell Company, Inc. The drill rig drove a hollow-stem auger with a 3.25-inch inside diameter. Core samplers were threaded onto sections of 2.5-inch solid steel rod driven by a 150-lb hammer having a 30-inch drop distance. The barge was also equipped with several large work tables used for extruding and processing samples and decontaminating equipment.

Two types of modified Dames and Moore Type U Samplers were employed to collect sediment cores. Sampling began at station T10A (Figure 2-10) with an 18-inch long stainless steel split-barrel sampler sent down the inside of the hollow-stem auger. The head (top end) of the sampler contained one-way check valves that allowed water to escape through holes while sediment entered the shoe (bottom end). A hinged steel flap or plastic spring-type core catcher fit into the shoe to ensure sample retention when the sampler was raised. Tenite butyrate formula 516 core liners manufactured by Eastman Kodak, Inc. were used inside the split barrel of the sampler. These liners were pre-cut into one-decimeter lengths with care taken to remove burrs and plastic shavings. Samples from Stations T10A, T2-1, and the deeper samples at T7-2 (7-910B and 7-2-1015) were collected using the 18-inch split-barrel sampler.

A second type of sampler was used after experiencing difficulty penetrating the deep sediments and retaining the core at station T10-1. The new sampler was 6 ft long and came apart into three 2-ft sections. The barrel was not split, and its 2.5-inch inside diameter did not allow for the use of core liners. An 8-by-1-inch stainless steel spatula was used to remove samples from each end of the 2-ft sections. Then a rubber stopper wrapped in aluminum foil was driven through the barrels from top to bottom to extrude the remaining samples. The shoe used with this sampler had an outside bevel instead of an inside bevel to penetrate the sediment more easily. It also had a built-in core catcher of eight hinged retainer plates which was more successful at retaining cores than the other types of core catchers used. Samples from stations T10-1, T13-2.5, T16-0, and the shallowest five decimeters from T7-2 were collected with the 6-ft sampler.

# 2.7.2.3 Sampling Procedures

Sampling procedures began when all four corners of the barge were firmly anchored and adjusted to position the drill rig on station. Thorough field notes were taken to document weather and wave conditions, water depth, dates and times, station positioning, workers present, equipment used, and all sampling activities.

Extreme caution was taken to avoid sample contamination at all times. The core sampler, core liners, shoe, and core catcher were thoroughly decontaminated and assembled by Parametrix personnel before each coring attempt. The sampler parts were scrubbed with a brush in a hot water Alconox soap solution, rinsed with hot tap water, rinsed with de-ionized water, rinsed with 20% HNO<sub>3</sub>, rinsed with de-ionized water, rinsed with methanol, and finally rinsed three times with de-ionized water. This sequence of

decontamination was also followed when preparing stainless steel spatulas, spoons, and bowls for extruding and compositing samples.

Samples were processed on the barge immediately after the core sampler was raised to the deck. Each core section was extruded into a separate stainless steel bowl and examined for physical characteristics. Sediment characteristic codes (Table 2-2) for grain size, color, odor, and debris were recorded on forms and in the field book. Each sample was thoroughly mixed resulting in composite samples of uniform color and texture from 10-cm depth increments. A minimum 125-mL aliquot of each sample was spooned into a wide-mouth plastic jar for metals and an equal quantity went into a glass jar for organics. These sample volumes were doubled for the deepest increment of each core to allow for quality control analyses. Decontaminated sample jars were provided by the laboratories performing the analyses. All sample jars were labeled with the station number, depth increment, date, time, analyses required and collector's initials, and placed on ice at 4°C.

# 2.7.2.4 Sample Handling

Marine sediment core samples were transported from the field to the Parametrix office in Bellevue, Washington. Chain-of-custody forms were prepared listing every sample number and the types of analyses required. Samples were packed on ice and shipped by express mail to the Asarco laboratory in Salt Lake City, Utah. Chain-of-custody records accompanied the samples to the laboratories, were signed by laboratory personnel, and copies were returned to Parametrix with analysis results. Microtox samples were delivered to the ECOVA laboratory in Redmond, Washington with the same custody protocol employed.

# 2.7.3 BIOLOGICAL INVESTIGATIONS

Studying the communities of marine invertebrate animals inhabiting sediments allows investigators to observe the relationship of these communities to their physical and chemical environment. To this end, ten marine benthos stations were selected to provide adequate spatial coverage of the project area. These stations attempted to provide a sampling of sediments encompassing the range of physical and chemical characteristics present in the project area. Two reference stations to the southeast of the project area were also sampled for benthos to provide a background comparison to the project stations.

All benthos sampling was conducted in July 1988 after the initial surficial chemistry and grain size results defined the heterogeneity in the project area. Station locations are provided in Figure 2-11. This figure also indicates the substrate type and metal pollutants found in the area. The reference stations T22-1 and T22-2 appear in Figure 2-9. All stations were located to within 1 m by the methods described in section 2.7.1 of this report.

All benthos samples were collected with a  $0.1\text{m}^2$  modified double van Veen grab sampler. Samples were judged acceptable if they met Puget Sound Estuary Program (PSEP) protocol (Tetra Tech 1986). This protocol says that the surface of the sediments in the grab must be relatively even and undisturbed. There must be overlying water to demonstrate no leakage and little disturbance, and the depth of sediment at the center of the grab must be at least 10 cm. In many cases, meeting the PSEP standard of 10-cm substrate penetration took a great many tries, and some of the stations in the original sampling plan had to be substituted with nearby stations where the grab would penetrate to a sufficient depth. After initial inspection, each  $0.1\text{m}^2$  grab was scooped and then rinsed into a clean bucket. Labels including station, date, depth, time, and replicate were added to each bucket immediately. When five replicate samples had been obtained, the buckets were transferred to the sieving station.

Samples were sieved at a site within view of the sampling station. The sieving station was either on a float, on another boat, or on the beach, depending upon where the samples were being taken. All samples were carefully screened with a 1-mm mesh sieve using gentle hose pressure to wash them while the sieve screen was submerged. The samples and their inside labels were then transferred to appropriate-size jars using a squeeze bottle and forceps to remove samples from screens. Jars were never filled more than half full to allow for proper fixation by the preservative. Samples were preserved with a solution of formalin (37% aqueous formaldehyde) diluted to ten percent with seawater and buffered with borax. Outside labels matching the inside labels were taped to the sides of each jar, and abbreviated labels were placed on jar lids.

Each day's samples were checked in at the Parametrix lab and cataloged. After at least 24 hours, the samples were removed from the formalin fixative and rescreened on a sieve screen of less than 1-mm mesh size. The rescreened samples were then transferred to a 70-percent ethanol solution with 1-g/l rose bengal stain added to make animals more visible to the sorters. Because of the porous nature of the slag material retained on the screens, large particles had to be broken with a mortar and pestle to ensure collection and enumeration of all organisms present within the pores. All internal and external labels were kept with the samples.

Samples were sorted at the Parametrix lab. For each sample, sediment volumes of 5 to 10 mL were sorted at a time in a petri dish under a dissecting microscope. Water was added and the sediment spread evenly over the bottom of the petri dish. The petri dish was then passed back and forth through the microscope viewing field until the entire dish was scanned. Organisms were removed during the scanning process and placed in vials labeled polychaeta, crustacea, mollusca, and miscellaneous. The sediment was then stirred and scanned a second time to obtain any remaining organisms. Large particles of debris (wood, bark, or clay) were removed from the sample, examined, and any organisms removed before the debris was returned to the original container. Organisms were preserved with fresh alcohol in the vials. An internal, waterproof, paper label was placed in each vial on which was recorded the station number, replicate, and date of collection. All sorted sediments were retained in labeled containers. General counts of each type of organism was recorded during sorting for later use in quality control. Following sorting into major taxonomic groups, each group was wet weighed separately

to determine biomass. Each group was weighed to the nearest 0.1-mg on a Sartorius analytical balance, and the data was recorded on a standard form.

Sorted taxonomic groups were sent to qualified taxonomists for identification to the lowest practical level. A chain-of-custody form accompanied each group of samples, and a copy of this form was returned to Parametrix with the data and samples when the taxonomists had finished their identifications.

A quality control (QC) check was conducted on each sample to ensure all of the organisms were sorted from the sample. This QC process began immediately following the initial sorting of the first few samples to prevent inadequate sorting of large numbers of samples. To perform the QC, a 20-percent aliquot of sediment was removed from each sorted sample after the sample was thoroughly mixed, and this aliquot was resorted. If the number of organisms recovered from this aliquot was more than one percent of the total number of organisms, the sample failed the QC test. All samples that failed the QC test were completely resorted by a different person.

# 2.7.3.2 Bioassays

Two types of bioassay tests were performed on surface sediments off the Asarco site: amphipod and oyster larvae tests. The station locations where sediment was sampled for bioassay testing are indicated on Figures 2-11 and 2-12. Samples were collected off the Asarco site and from reference areas located to the north and south of the site. Sediment samples were collected using the same techniques described in Section 2.7.1, Surficial Sediment.

All sediment samples collected for bioassay tests were analyzed for complimentary chemistry data. Sediments destined for each type of analysis (biological and chemical) were homogenized in a stainless steel bowl before apportioned into their respective containers. Bioassay samples were placed in glass jars and retained on ice to the Parametrix Laboratory where the bioassay tests were performed.

# Amphipod (Rheoxynius abronius) Bioassay

The procedures used in the amphipod bioassay are those of Swartz, et al. (1985) including modifications specified by Tetra Tech (1986). Sediment samples were homogenized and placed in five replicate 1-L beakers to a depth of 3 cm. Filtered, UV-sterilized seawater from the amphipod collection site was added to the test beakers with sorters taking care not to disturb the sediments. Twenty amphipods, field collected 4 to 6 days earlier, were carefully placed into each beaker. The beakers were covered with black plastic to maintain a dark environment for the amphipods. The beakers were maintained at  $14 \pm 0.5^{\circ}$  C in a water bath. Daily observations were made over a 10-day period. Sorters noted the number of individuals on the water surface, in the water column, and on the sediment. After 10 days, the test was terminated and all amphipods were sieved out of the sediments in each beaker and counted as either dead or alive. The animals were determined dead if no movements were observed following prodding with a glass rod.

Water chemistry was monitored daily using separate "chemistry" beakers to avoid cross-contamination by instrumentation probes. These beakers were monitored for salinity, temperature, dissolved oxygen, and pH.

A positive control consisting of a three replicates utilizing a reference toxicant (CdCl<sub>2</sub>) concentration of 1.68 mg/L was done to determine the 96-hr  $LC_{50}$  value for the test animals used. A negative, or clean sediment, control was employed. The control consisted of fine sand from the amphipod collection site.

# Oyster (Crassostrea gigas) Larvae Bioassay

The procedures used in the oyster larvae bioassay were those described by ASTM (1985) including modifications specified by Tetra Tech (1986). In brief, sediment samples were homogenized and 20 g were placed in 5 replicate 1-L glass jars. One L of clean, filtered, UV-sterilized seawater was added to each jar. The jar was sealed, inverted five times, and allowed to settle at least one hour prior to inoculation.

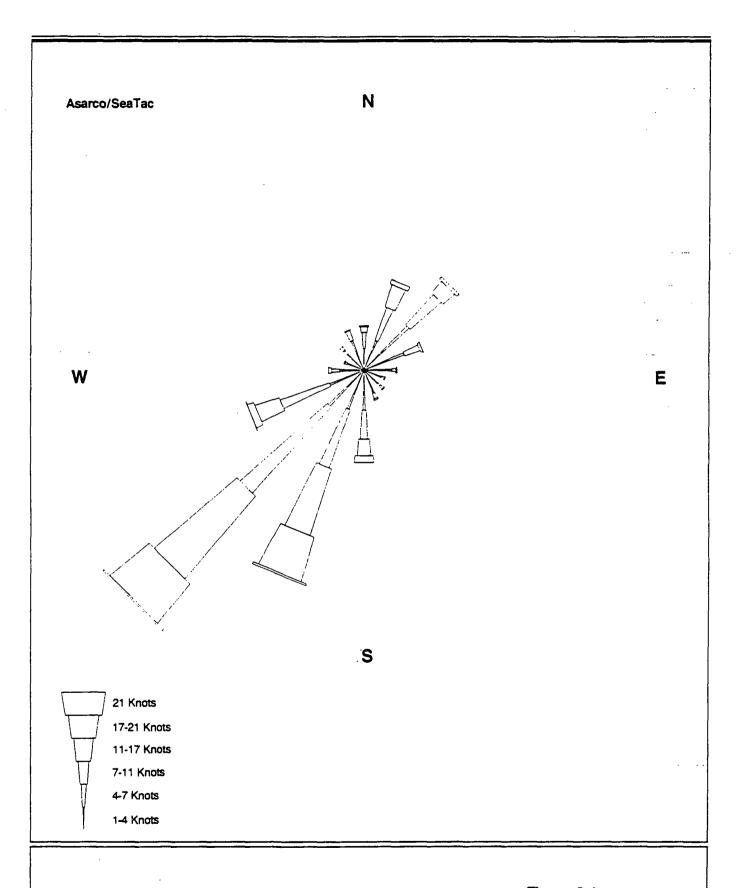
Water chemistry parameters were monitored at the beginning and end of the 48-hr test from separate "chemistry" jars to avoid cross-contamination by instrumentation probes. The parameters measured were salinity, dissolved oxygen, pH, and temperature.

Broodstock oysters were obtained from Coast Oyster Co., Quilcene, Washington and spawned by hot and cold shocking. About one hour after fertilization the embryo stock solution density was determined. Embryo density was adjusted so that a 10-mL inoculation would deliver an estimated 20,000 to 30,000 embryos to each treatment jar. After inoculation, very gentle aeration was applied, as prior experience had indicated that dissolved oxygen levels would drop below acceptable levels without aeration.

One set of negative (clean) and one set of positive (toxic) controls were employed. The seawater negative control consisted of UV-filtered natural seawater collected in Puget Sound. Two sets of reference sediments from transects adjacent to but distant from the Asarco site were also tested. A positive control consisting of a series of tests using a progression of five reference toxicant (CdCl<sub>2</sub>) concentrations ranging from 0.0002 to 0.002 g/L was performed to determine the 96-hr  $LC_{50}$  value for the test animals used.

Oyster larvae were incubated for 48 hours at 20°C. Under normal conditions, by this time they would be expected to metamorphose into the prodissoconch I or "straight hinge" stage. Water was carefully poured out of the test jar into a clean beaker leaving only the sediments behind. The supernatant seawater was thoroughly mixed and a 10-mL aliquot taken. This aliquot was preserved in 5 percent buffered formalin. Control counts were made during the initial inoculations, and these counts were used to predict the survival in each treatment vessel. Percentage survival was calculated as a proportion of this expected value.

Larval counts were made in settling columns at 100x using an Olympus CK2 inverted microscope. Larvae were considered abnormal if they were malformed or had not developed to the prodissoconch I stage.

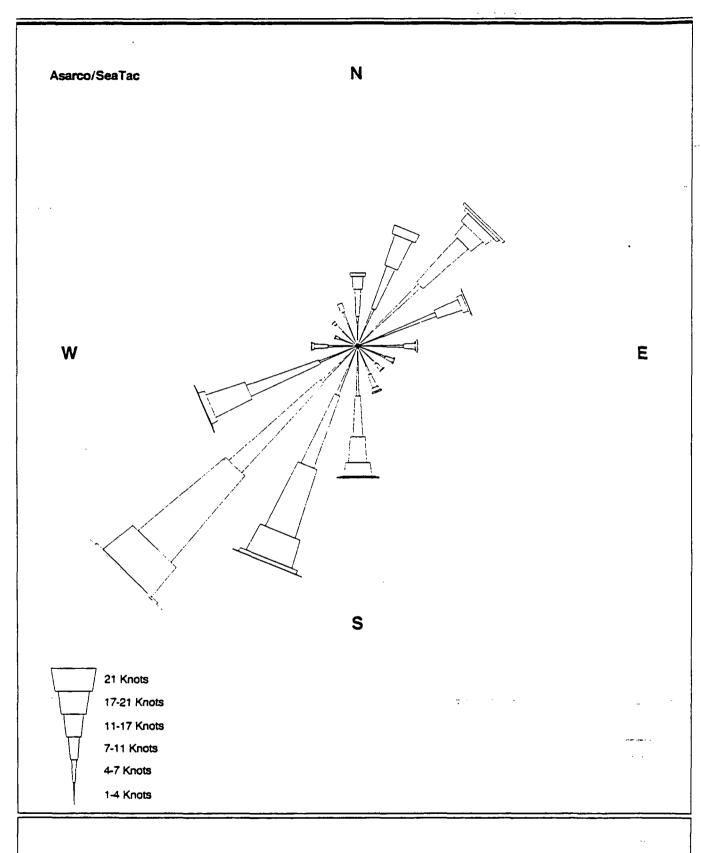


Calms = 0.0%

Peak Direction ≈ SW

Peak Frequency = 24.6%

Figure 2-1. Wind Rose for Data From 1/1/84-12/31/84

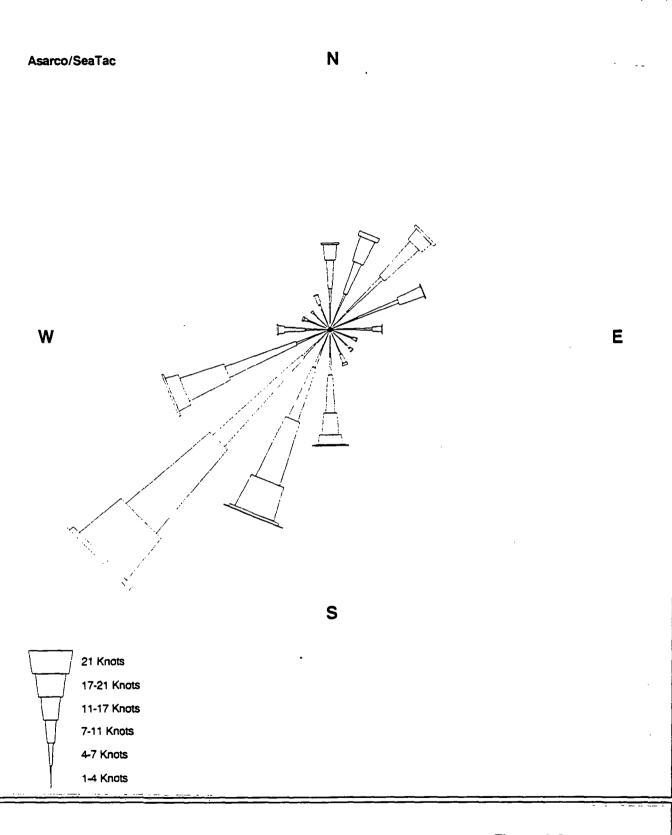


Calms = 0.0%

Peak Direction = SW

Peak Frequency = 19.2%

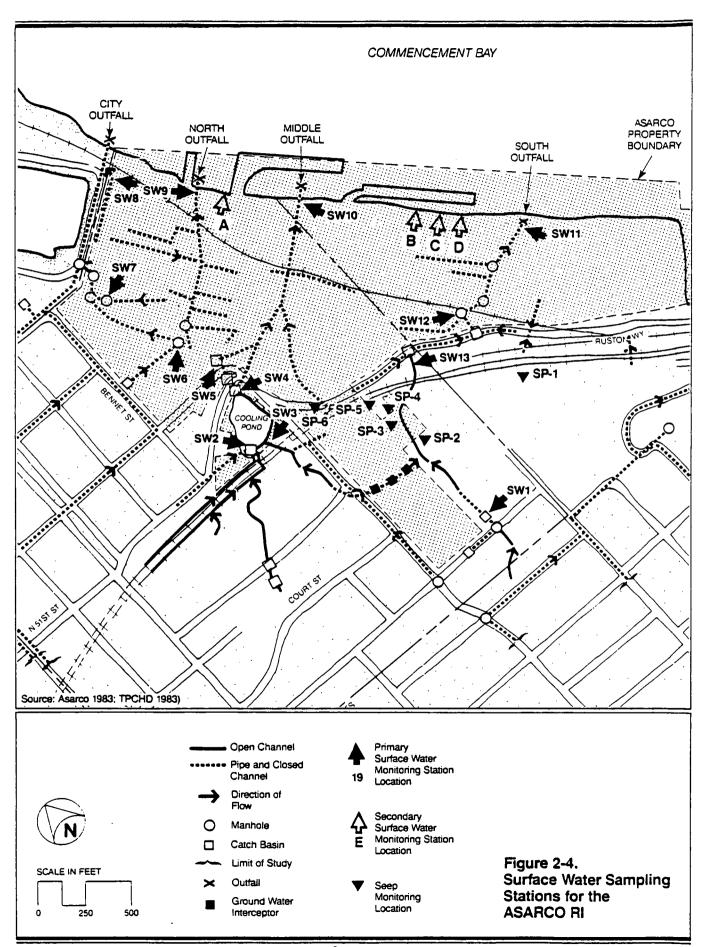
Figure 2-2. Wind Rose for Data From 1/1/83-12/31/83



Peak Prequency = 21.2%

Calms = 0.0%

Figure 2-3. Wind Rose for Data From 1/1/82-12/31/82



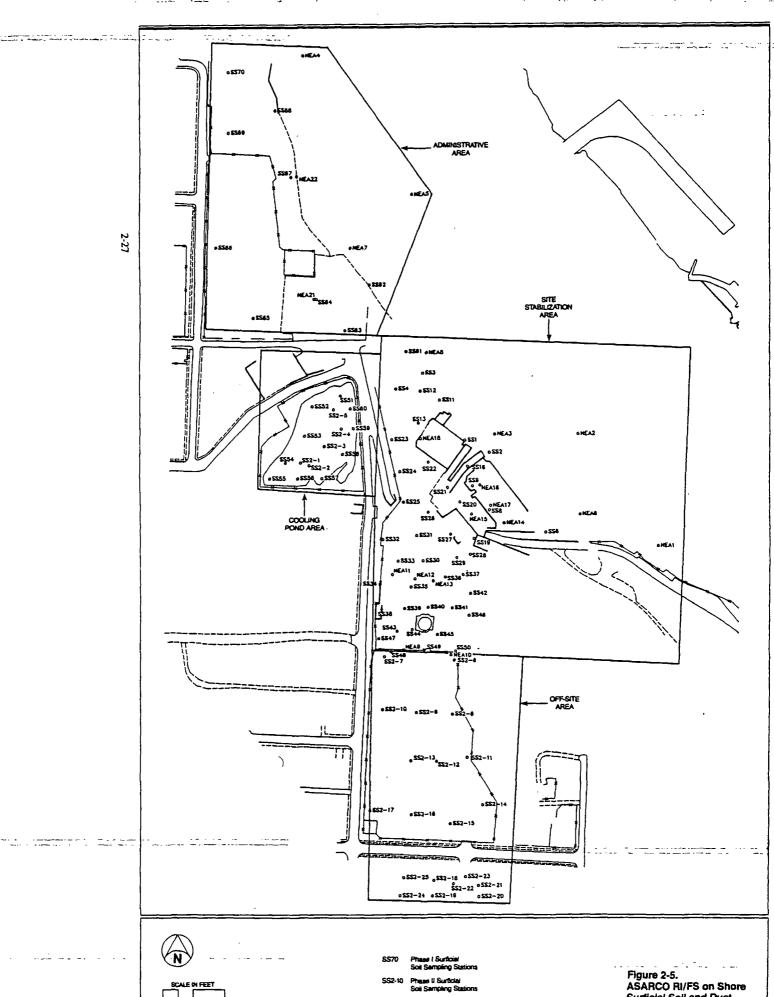
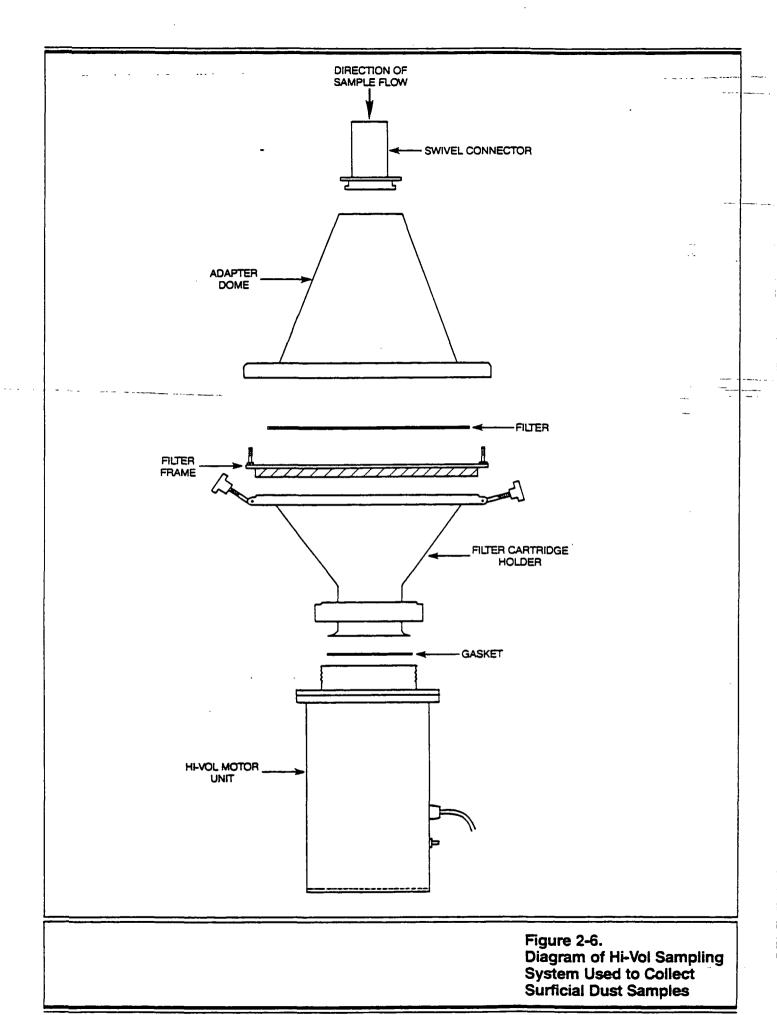
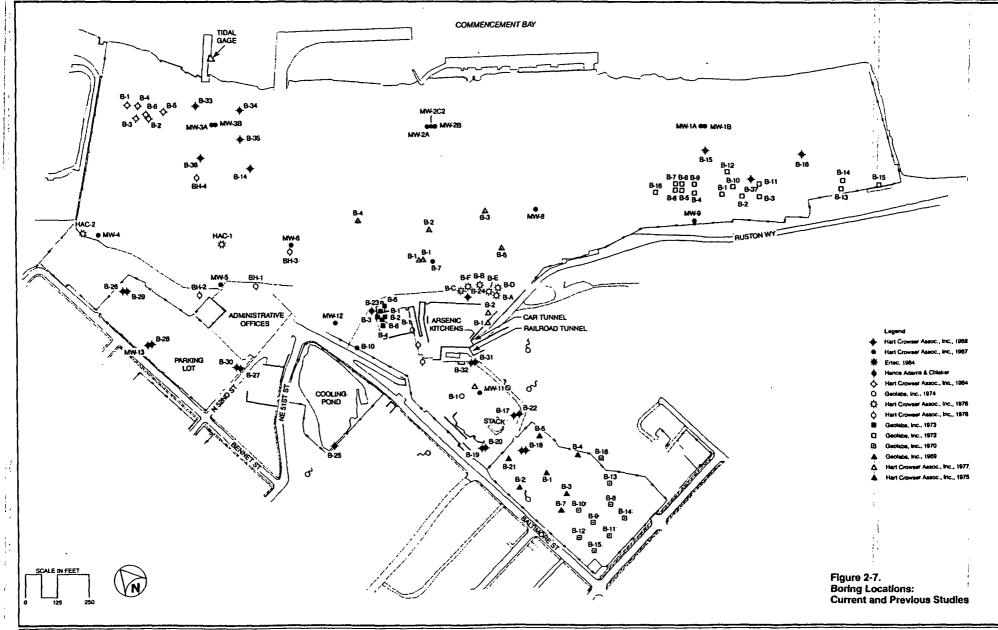
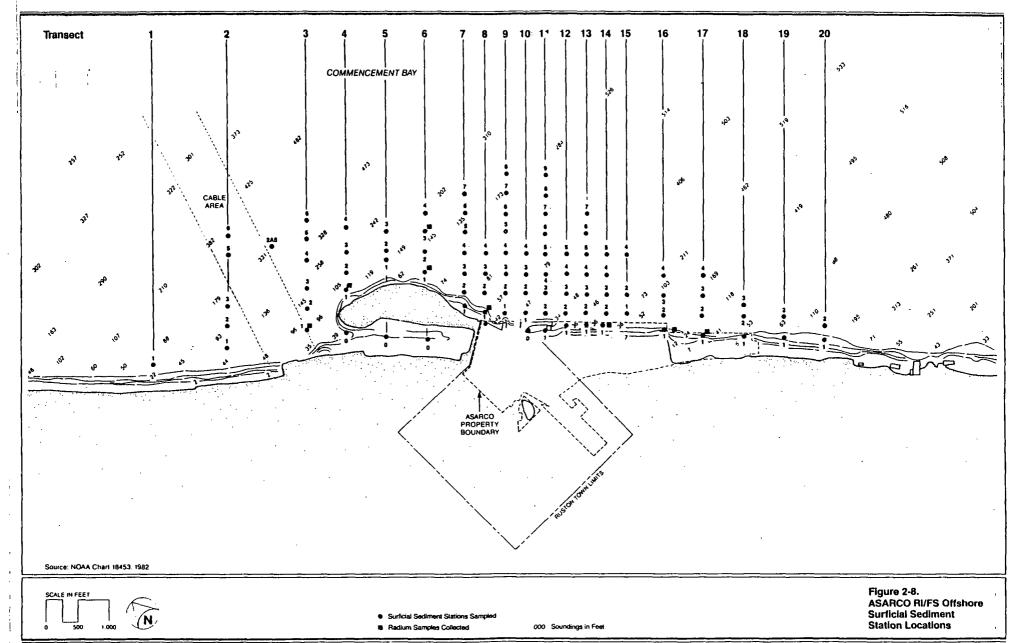
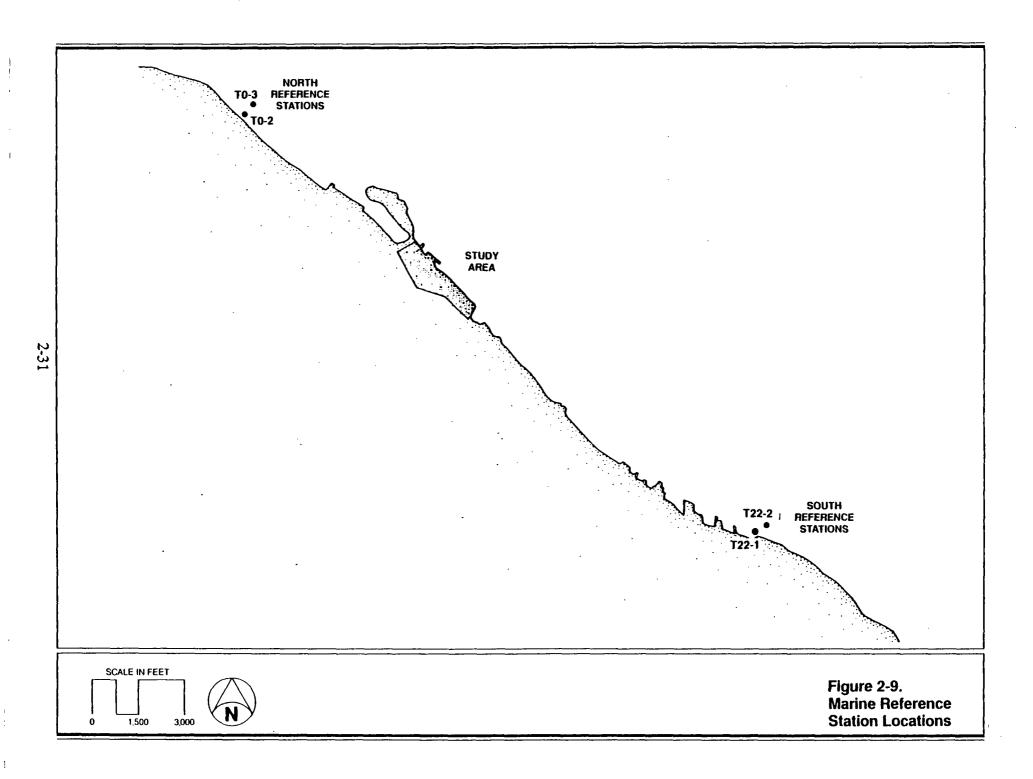


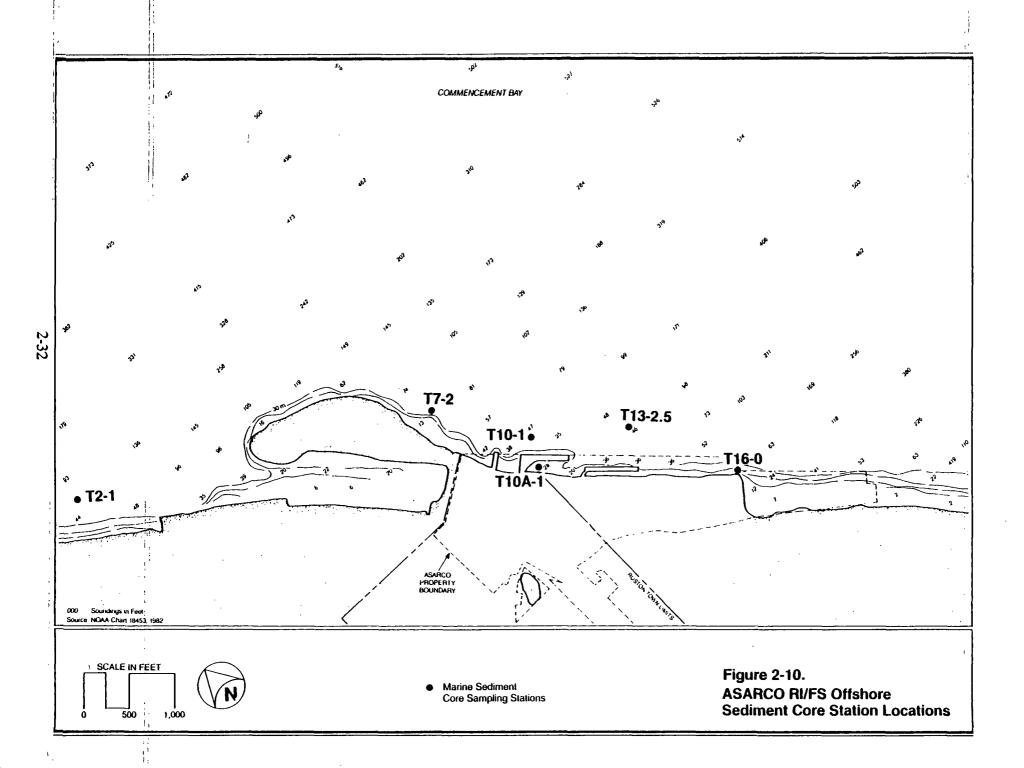
Figure 2-5. ASARCO RI/FS on Shore Surficial Soil and Dust

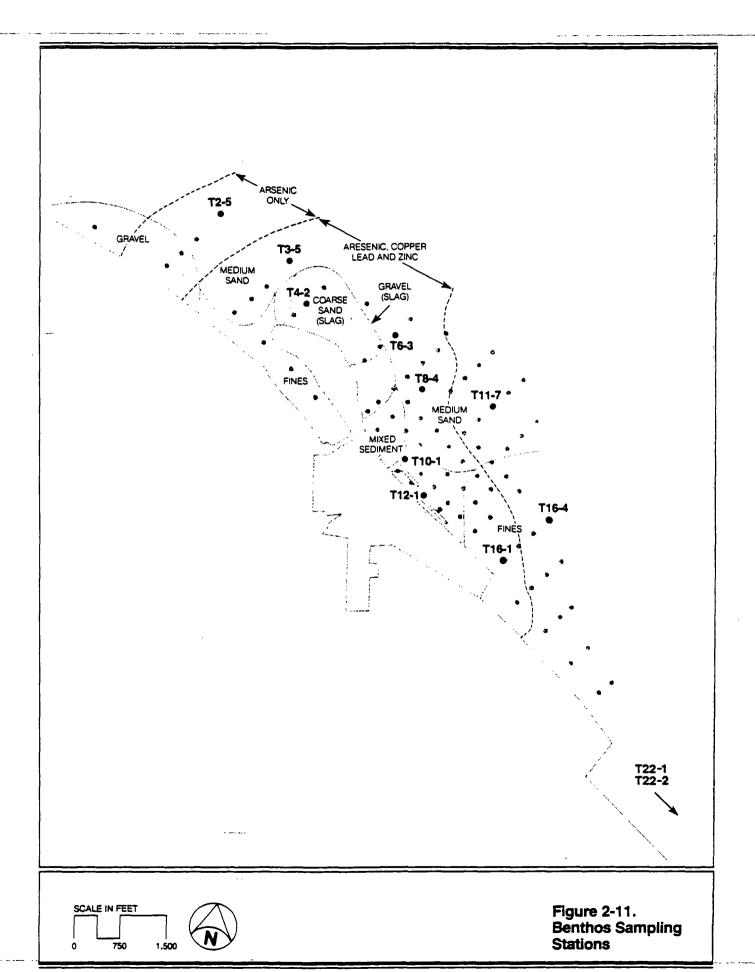


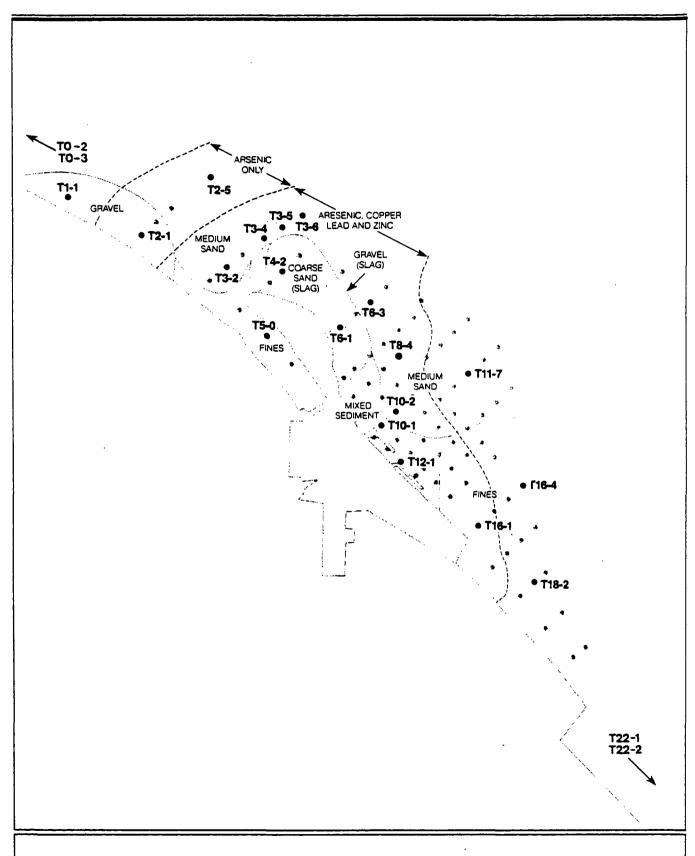












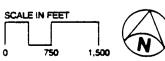


Figure 2-12. Bioassay Stations

# 3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

# 3.1 SURFACE FEATURES

An aerial photograph generated site topography map was created to describe the existing site features and contour elevations. Figure 3-1 depicts the existing site topography.

### 3.2 AIR QUALITY

No field studies were conducted to determine physical features that may affect air quality. For the modeling efforts described in Section 2.2, existing data were used. Some new data were collected that addressed the relationship between chemical contamination and particle size distribution. The results of this work and the interpretation of these data are presented in Section 4.1.

#### 3.3 SURFACE WATER HYDROLOGY

#### 3.3.1 RAINFALL

Hourly rainfall data is presented in Figure 3-2. Data for Event 1 is from a continuous recording at the City of Tacoma's 26th and Pearl gauge. Data for Event 2 is from a continuous recording at the City of Tacoma's central treatment plant gauge. Data for Event 3 is from hourly recordings at Asarco's gauge.

Approximately 0.15 inches of rainfall accumulated during each sampling period. Rainfall intensity was moderate to low, which is typical for the Puget Sound area. The maximum intensity was 0.08 inches per hour (Event 1).

The sample period for Event 1 began after about 0.17 inches of rainfall had accumulated in six hours. The sample period for Event 2 began at the onset of rain. The sample period for Event 3 began after it had rained 0.07 inches in two hours. It had not rained for four days before Event 1, while it rained the day before Events 2 and 3.

#### 3.3.2 MIDDLE OUTFALL

Stations in the middle outfall catchment area include SW-2, SW-3, SW-4, SW-5, and SW-10 (Figure 2-4). Water enters the Asarco site at SW-2 where it is routed along an aqueduct around the cooling pond. Water from outside the Asarco site mixes with some water from the stack area and enters the cooling pond aqueduct at SW-3. These combined waters leave the cooling pond area at SW-4 and enter the subsurface drainage system in route to the middle outfall (SW-10). SW-5 collects street runoff (near Asarco's entrance gate) and flows to the middle outfall.

Hydrographs of the middle outfall stations are presented for each event in Figure 3-3. Because of the short distances between stations, flows respond quickly to rainfall intensity, and there is not much of a lag time between stations.

During peak flow, about 50 percent of the outfall flow is at SW-2 and 75 percent of the outfall flow is at SW-4. Thus, about 25 percent of the outfall peak flow is drainage from other areas between SW-4 and SW-10. During base flow, SW-4 has a flow similar to the middle outfall (SW-10). This suggests that not much water is exchanged between the groundwater and surface water through the Asarco site upgradient of the middle outfall. If a large amount of groundwater was seeping into the drainage system, then there would be a greater difference in base flow at SW-4 and SW-10. If a large amount of surface water was seeping out of the drainage system, then there likewise would be less difference in peak flow at SW-4 and SW-10.

Flows at the middle outfall are somewhat affected by tides. The high tide level during the last two hours of Event 2 had backed-up water at SW-10. Water was still flowing at SW-10; however, and conductivity measurements verified the slow flowing water was not marine water.

#### 3.3.3 SOUTH OUTFALL

Stations in the south outfall catchment area include SW-1, SW-13, SW-12, and SW-11 (Figure 2-4). Station SW-1 is located at the head of the catchment area. Water flows along an open channel from SW-1 to SW-13. Groundwater seeps (SP-1 through SP-5) flow into this channel. Water then flows in drainage pipes from SW-13 to SW-12 and on to the south outfall (SW-11).

Flows at the south outfall are strongly dependent on tides. Water backs up the drainage pipe between SW-12 and SW-13 at high tide. When the tide begins to go out (ebb tide), high flows occur at the outfall. This tidal effect was observed during the first hour of Events 1 and 3, which were monitored during an ebb tide (Figures 3-2 and 3-4). Conversely, when the tide comes in (flood tide) and approaches high tide, no flow occurs at the outfall. This effect was observed during the last two hours of Event 2, which was monitored during a flood tide (Figures 3-2 and 3-4). Conductivity measurements identified marine water in the last hourly sample of Event 2.

Because of tidal influence, flows in the south outfall catchment area are best compared at low tide. Low tide occurred at the end of Events 1 and 3, and at the beginning of Event 2. At this time, flow at the outfall is substantially less than flow at SW-12. This suggests a large quantity of water is lost from the drainage system from SW-12 to the outfall (SW-11) and enters the groundwater system. Groundwater investigations support this conclusion (see analysis of groundwater level and precipitation in Section 3.6.3.5).

#### 3.3.4 NORTH OUTFALL

The only station in the north outfall catchment area is the outfall itself (SW-9). Water from stations SW-6, SW-7, and SW-8 flows to a City of Tacoma outfall located north of the north outfall (Figure 2-4). Water at SW-6 comes from the parking lot east of Bennet Street. Water at SW-7 comes from the area around Asarco's No. 1 Refinery. Water at SW-8 drains a small area along Asarco's northern property line.

Flows at the north outfall are somewhat affected by tides. Tidal influence is less at the north outfall than the middle outfall. However, the high tide level during the last two hours of Event 2 had backed-up water at SW-9. Conductivity measurements verified that this backed-up water was not marine water.

#### 3.4 SURFACE SOIL

Most of the Asarco Tacoma smelter project site is paved. The eastern portion of the site bordering Commencement Bay is almost completely covered with asphalt or concrete. Very little actual surface soil is exposed. Based on surface soil sampling results, the exposed soil on the project site can be divided into roughly four areas: the plant administrative area, the cooling pond area, the site stabilization area and off-site area (see Figure 2-5).

# 3.4.1 PLANT ADMINISTRATIVE AREA

Much of the surface soil in the plant administrative area has a layer of slag particles on top of it, ranging from one to three inches thick. Some areas have a "crust" of organic matter such as humus and plant material. The soil itself appeared to be sandy fill material mixed with gravel, slag, cobbles, and, in some areas, crushed brick.

#### 3.4.2 COOLING POND AREA

In contrast to the soils in the administrative area, the soils around the cooling pond were finer. Many sampling locations had silty or clayey soil composition. When samples SS-58, 59 and 60 were collected, a hard clay layer was encountered at 8 to 10 inches depth. However, some of the soil samples appeared to be the more common sand mixed with clay.

#### 3.4.3 SITE STABILIZATION AREA

Much of this area, like the administrative area, was covered by one to two inches of slag. In general, soils were sand mixed with gravel or sandy clay mixed with cobbles. Very commonly samples collected contained demolition debris consisting of concrete rubble, wood debris, slag chips and broken pieces of brick. Some of the area was covered by organic matter such as ferns and humus.

It was determined that soils from this area exhibited a "limited reservoir of erodibility" because most of the soils had a crust > 0.6 cm thick, and it was not easily crumbled (Cowherd 1985). Dust samples were collected for particle size distribution analysis. However, there was not enough dust present after site stabilization activities to conduct this analysis at individual sampling stations.

#### 3.4.4 OFF-SITE AREA

The off-site area is comprised of three areas or vacant lots, mostly covered with vegetation such as plants, trees and grasses. Surface soils sampled in these areas were mostly sandy loam and gravel. The two larger off-site areas that were sampled were secured by a locked fence. The smaller lot was unsecured and between two residences.

#### 3.5 SUBSURFACE SOIL

#### 3.5.1 INTRODUCTION

The current understanding of the subsurface distribution of geologic units was developed from subsurface explorations completed during Phase I and Phase II drilling and sampling plus previous explorations as shown on Figure 3-6. Figure 3-7 shows the stratigraphic column for site geologic units. Figure 3-8 shows the surface distribution of geologic units. Geologic cross sections are shown on Figures 3-9 to 3-16. Figure 3-17 shows a contour map of the fill thickness (isopach map). In the following discussions only Phase I and II borings are referenced unless otherwise noted.

# 3.5.1.1 Location of Supporting Information

Appendix B contains details of the field data exploration program. This information includes details of borehole drilling, sub-surface soil sampling, well construction, groundwater sampling, hydraulic conductivity testing and water level measurements. Boring logs and well construction diagrams are also found in Appendix B. Appendix C contains boring logs for wells drilled before this investigation and used to develop geologic cross sections. Appendix D contains details of the laboratory testing program for subsurface soils.

#### 3.5.1.2 Elevation Datum

Elevations presented in this report are based on the City of Tacoma (COT) datum which is about 14.0 ft below mean sea level (National Geodetic Vertical Datum [NGVD] of 1929). Mean lower low water (MLLW) level is located 6.32 ft below mean sea level. Therefore, a correction of +7.68 ft was added to MLLW (tide chart data) to obtain water levels with respect to the COT datum.

# 3.5.2 SUMMARY OF SUBSURFACE SOIL CHARACTERISTICS AND DISTRIBUTION

The Asarco site can be divided into three general geographic areas with geologic deposits of differing depositional environments, lithologies and water-bearing characteristics. This section and the following section (3.6 Groundwater) discuss the site's subsurface soil and hydrogeologic characteristics in the context of these areas. These geographic areas are shown on Figure 3-6 and are referred to as the Plant, Parking Lot and Stack areas.

The soils encountered on the site have been divided into six assemblages of stratigraphic units for discussion purposes. These assemblages have been further divided into site geologic and hydrogeologic units as shown on Figure 3-7. Geologic units are given names for discussion and reference purposes only. In Section 3.6, Groundwater, geologic units are grouped into units exhibiting similar hydraulic characteristics. These are termed "hydrogeologic units." The relationship between geologic and hydrogeologic units is illustrated on Figure 3-7. Within each area, these units are described from youngest to oldest.

#### 3.5.2.1 Plant Area Subsurface Soils

The Plant Area is the largest area within the Asarco site. Soils found in the Plant Area include manmade fill deposits, recent alluvial (stream or flood deposits) and beach deposits, Vashon Advance Silt, and Pre-Vashon sand and silt.

## Fill Deposits

Fill deposits include granular, slag, and wood waste fills. These deposits reach their maximum thickness of 45 ft in the northeast portion of the site. Fill was used to reclaim the former tidelands at the base of the sea cliffs. Fills are found principally east of the original shoreline and adjacent to and above the Arsenic Kitchens area on the hill leading up to the Stack.

# Recent Deposits

Recent deposits include alluvium and beach sands. The alluvium is composed of sands and silts deposited in the pre-fill gully underlying the cooling pond and the MW-12 and B-10 boring locations. Beach sand is found on the east side of the site and directly underlies the fill deposits.

## Vashon Advance Deposits

Vashon Advance deposits consist of a thick sequence of hard silt with varying amounts of sand and clay. Its thickness ranges from about 25 ft in the north to over 55 ft in the southern portion of the plant area. This geologic unit is an effective aquitard within the Plant Area.

#### **Pre-Vashon Deposits**

Pre-Vashon deposits consist of a silty, gravelly sand. Only one boring penetrated this unit in the eastern portion of the Plant Area (B-14). This unit is water bearing.

## 3.5.2.2 Parking Lot Area Subsurface Soils

Soils in the Parking Lot Area consist of Vashon glacial, Pre-Vashon glacial, and non-glacial deposits.

#### Vashon Deposits

Vashon deposits are a result of the advance and retreat phase of the Vashon stage of the Fraser Glaciation (Armstrong 1965). These deposits include recessional sands and gravel, till and advance sand, and gravel. Vashon soils were deposited on the Pre-Vashon erosional surface, which was highly irregular. These deposits are about 50 ft thick in the Parking Lot Area. Vashon deposits and the underlying pre-vashon deposits support seasonally saturated and perched water zones.

# Pre-Vashon Deposits

Pre-Vashon soils are represented by a sequence of glacial and non-glacial deposits. Pre-Vashon soils have been lumped into two groups: the Pre-Vashon Sand, Silt and Lignites and Pre-Vashon Gravel. The Pre-Vashon soils include glacial till and outwash materials as well as non-glacial deposits consisting of silt and lignite. The combined thickness of this unit is 20 to 30 ft. The Pre-Vashon Gravel is found below the Pre-Vashon Sand, Silt and Lignite unit and consists of a very sandy gravel. Although the thickness of the Pre-Vashon Gravel was not defined in this investigation, the Pre-Vashon gravel is likely connected to the regional aquifer to the west and the Fill Aquifer to the east.

#### 3.5.2.3 Stack Area Subsurface Soils

The subsurface soils in the Stack Area consist of a thin veneer of Granular Fill underlain by a thick sequence of Vashon Advance Sand and Vashon Advance Silt. The sand layers were encountered directly beneath the Granular Fill and as thin interbeds within a thick sequence of silt with varying amounts of sand and clay. Vashon Advance Silt was continuously mapped from shallow depths on the Stack Hill, at elevation 155 to beneath the Plant area as low as elevation -65 ft. The sand interbeds are water bearing while the silt is a competent aquitard that restricts the downward movement of water.

A detailed discussion of the geologic units found on-site follows.

#### 3.5.3 PLANT AREA GEOLOGIC UNITS

Plant area geologic units include the following:

- Granular Fill (Fg)
- Wood Waste Fill (Fw)
- Slag Fill (Fs)
- Alluvium (Qal)
- Recent Marine Sand (Qm)
- Recent Marine Silt (Qms)
- Vashon Advance Silt (Qvs)
- Pre-Vashon Sand (Qus).

# 3.5.3.1 Fill Deposits

Fills at the site include granular soil, wood waste materials, and slag. Granular soil fill is interbedded at sea level with beach lag gravels. Sawmills predating the smelter produced a deposit of wood waste up to 6 ft thick, which overlies beach gravel. Slag, ranging from less than 1 to 43 ft thick, overlies granular soil, wood waste, and beach gravel deposits. The eastern limit of fill is the present shoreline of Commencement Bay except where it is adjacent to and above the Arsenic Kitchens.

# Granular Fill (Fg)

Granular Fill is typically loose-to-medium dense, gravelly sand probably excavated from the hillsides of the site, at least in part from the parking lot area of the northwestern portion of the site. The thickness of Granular Fill is quite variable across the site and often includes bricks and some wood. Figure 3-17 shows an isopach map (fill thickness contour map) of the fill on site. Isopachs in the upland area west of the original shoreline generally reflect the thickness of the Granular Fill materials.

## Wood Waste Fill (Fw)

Wood waste is found in a layer (up to 6 ft) over beach gravels and below Slag Fill. This deposit was produced by sawmill operation in what is now the southern portion of the property near the SO<sub>2</sub> plant (locations B-1, B-15 and B-37). Wood Waste Fill is also found in the northern portion of the site as a thin lens in wells B-14 and B-35. Sections A and E (Figures 3-9 and 3-13) show the thickness of the Wood Waste Fill. This material is a soft, wet, black bed of wood chips and sawdust that emits a strong sulfurous odor characteristic of decaying wood material. This deposit probably underlies several acres of the Slag Fill in the marine environment near the site.

#### Slag Fill (Fs)

Slag Fill is variable in textural composition and is present generally within the eastern portion of the site as shown on the surface geologic map (Figure 3-8) and Sections A through H (Figures 3-9 through 3-16). Slag is present from below sea level to 26 ft in elevation. These deposits form a dense, gray-black vesicular mass that is fractured to massive in texture. At the surface, slag is often massive; at elevations from sea level to 20 ft (average high tide level) slag typically exhibits a hackly fracturing pattern that causes a high permeability. Slag Fill includes a variety of other materials including scrap steel, logs, and lumber. Black, viscous oil was encountered in borings B-3A, B-33 and B-36 in the Slag Fill at a depths of 11 to 33 ft below the ground surface (about elevation 16 to -6 ft). The Slag Fill is a seaward thickening, wedge-shaped deposit ranging from less than 1 up to 43 ft thick.

# 3.5.3.2 Plant Area Recent Deposits

Recent deposits within the Plant Area include native alluvium, beach gravel and sand, and marine silts. Native deposits typically contain some naturally occurring organic material: shells in marine deposits; and plant materials, wood, or roots in alluvial deposits. Recent deposits occur in the gully that contains the cooling pond and beneath the Slag Fill.

# Alluvium (Qal)

Alluvium includes three general types of fluvial deposits: (1) soft-to-medium-stiff, gray, slightly gravelly to non-gravelly clayey silt; (2) stiff-to-very-stiff green silt with many roots and woody materials; or (3) very dense, slightly silty, very gravelly sand. Alluvium occurs near the original shoreline (MW-6) and in the pre-fill gully underlying MW-12, B-10, and the cooling pond (B-25) Section C (Figure 3-11).

# Recent Marine Sand (Qm)

Recent Marine Sand is medium-dense, gray-to-light gray, silty, sand with varying amounts of gravel with abundant shell fragments and occasional wood fragments. This material underlies the Slag Fill at the site. It has a wedge-shaped geometry thickening shoreward and varies in thickness from 1 ft (Boring B-6, Hart Crowser 1975a) to 15 ft (Boring B-15). This material probably represents original shoreline beach deposits and was penetrated by wells B-2A, MW-6, MW-8, MW-9, B-14, B-16 and B-35. Sections A through H with the exception of Section C (Figures 3-9 through 3-16, except Figure 3-11) show the distribution and thickness of this unit.

# Recent Marine Silt (Qms)

The Recent Marine Silt is a greenish gray, sandy silt with shell fragments. The distribution of this unit is shown on Sections B, F, and G (Figures 3-10, 3-14, and 3-15). This unit appears to be present only in the east central portion of the plant area and is not present in B-14 to the north and B-15 to the south.

The Recent Marine Silt is generally less than 10 ft thick and is present from about elevation -20 to -30 ft (MW-2C2). This unit grades both laterally toward the west toward B-4 (Hart Crowser 1975b) to a medium stiff gray to brown clayey silt. This material underlies the Recent Marine Sand and directly overlies the Vashon Advance Silt unit.

# Vashon Advance Silt (Ovs)

The Vashon Advance Silt consists of a thick sequence of mostly stiff to hard gray, evenly laminated silt with varying amounts of fine sand and clay. It appears that this unit correlates to the silt units found in borings close to the Arsenic Kitchens (B-7, B-10, B-23 and B-24) and on the Stack Hill in borings B-17, B-18 and B-19. The stratigraphic relation between these borings are illustrated in Sections A and B (Figures 3-9 and

3-10). This unit can be mapped on-site from elevation of about 140 ft (B-18) to at least-65 ft (B-15) and most likely rests on the Pre-Vashon topographic surface.

# Pre-Vashon Sand (Qus)

The Pre-Vashon Sand consists of a very dense, very-silty-to-silty, gravelly to very gravelly sand. This unit is found in borings B-14, B-2C2 and B-4 (Hart Crowser 1975b). This unit is water bearing and is monitored by one well, B-14. This unit is about 10 ft thick in well B-14. The lateral extent of this unit is unknown but appears to correlate with the Pre-Vashon deposits in the Parking Lot Area. It is identified as being Pre-Vashon age by the presence of organic fragments.

#### 3.5.4 GEOLOGIC UNITS OF THE PARKING LOT AREA

The interpretations of the stratigraphic relationships for Parking Lot area are shown in the geologic cross-sections C and D shown on Figures 3-11 and 3-12.

The stratigraphic units of the Parking Lot Area include the following:

Glacial Units of the Vashon Drift (Qv) including:

- Vashon Recessional (Qvr)
- Vashon Till (Qvt)
- · Vashon Advance Sand (Qva).

Pre-Vashon Drift Unit (Qu) including:

- · Pre-Vashon Sand, Silt and Peat (Qus)
- · Pre-Vashon Gravel (Qug).

## 3.5.4.1 Vashon Drift

Vashon Drift is represented by a sequence (youngest to oldest) consisting of Recessional Deposits, Till, and Advance Sand. Vashon Drift rests on the erosional surface of the Pre-Vashon sediments. Vashon Drift was deposited during the advance and retreat phases of the Vashon stage of Fraser Glaciation (Armstrong et al. 1965).

## Vashon Recessional Deposits (Ovr)

Vashon Recessional Deposits are composed of medium-dense-to-dense, gravelly sand to sandy gravel. This unit rests on Vashon Till at elevations above 90 ft on-site in the western most portion of the Parking Lot Area (Well B-29), as shown in Section C (Figure 3-11).

## Vashon Till (Ovt)

Vashon Till is a crudely stratified, very dense, gray-to-brown, silty, gravelly sand. This material is about 30 ft thick underlying the parking lot area and was encountered in wells B-27, B-29 and MW-13 as shown on Figure 3-8 and Sections C and D, (Figures 3-11 and 3-13) at elevations from 50 to 90 ft. This unit represents the most recent till in the area, overlying an older glacial sequence (Pre-Vashon unit) which is exposed below the parking lot.

# Vashon Advance Sand (Qva)

Vashon Advance Sand deposits include very dense, brown, slightly silty, gravelly sand which lies stratigraphically below Vashon Till (Qvt). They are approximately 5 to 7 ft thick, and are found at elevations ranging from 40 to 65 ft as shown on Sections C and D (Figures 3-11 and 3-13).

The Vashon Advance Sand also lies directly below the Granular Fill material and is interbedded within the Vashon Advance Silt within the Stack Area (Figure 3-16). It is composed of medium dense, brown, silty, fine sand to dense, brown, clean, fine sand. The presence of the Vashon Advance deposits within the Stack Area compared to where it is found in the Parking Lot area is due to the topographic relief of the Pre-Vashon erosional surface in these areas.

# 3.5.4.2 Pre-Vashon Unit (Qu)

The Pre-Vashon Unit (Qu) is composed of Pre-Vashon glacial till and outwash material. Grouped within this unit are also non-glacial material including silt/lignite and gravel deposits. The Pre-Vashon unit, shown in Section C and D (Figures 3-11 and 3-12), is the most extensive unit in the Parking Lot Area. It is found at elevations from 60 ft (MW-13 and B-29) to 10 ft (B-27) and is also found beneath the Vashon Advance Silt within the Plant Area in borings B-14 and B-2C2 at elevation -30 ft. This difference in elevation is due to the topographic relief of the Pre-Vashon erosional surface.

#### Pre-Vashon Sand, Silt, and Lignite (Qus)

The Pre-Vashon Sand, Silt and Lignite consists of interbedded very dense, silty gravelly sand to gravelly to non-gravelly sand. These soils represent a Pre-Vashon Till and Outwash deposit. The combined thickness of the Pre-Vashon Sand, Silt, and Lignite is 20 to 30 ft thick and is found at elevations of -5 to 55 ft in wells MW-4, MW-5, MW-13, B-26, B-27, and B-29.

In the lower portion of the Pre-Vashon Sand, Silt and Lignite is a sequence of hard, sandy, silty lignite (compact peat), organic silt, and tufaceous sand. Two layers of lignite have been identified within the Pre-Vashon Sand, Silt, and Lignite. The first was identified in wells MW-13 and B-26. This layer is 4 to 7 ft thick at elevations of 40 to 50 ft. This unit appears to support a zone of perched water in the overlying Pre-Vashon deposits but pinches out toward B-27 as shown on Section C, (Figure 3-11).

The second lignite layer is a 10-ft-thick unit of hard, black, slightly sandy, silty lignite occurring between elevations -1 ft and 9 ft (MW-5, Figure 3-12). It is interbedded with a 4-ft-thick deposit of gray sand. These lignite layers appear to be discontinuous; their lateral extent is unknown.

# Pre-Vashon Gravel (Qug)

The Pre-Vashon Gravel consists of a gray-brown, slightly silty, very sandy gravel found from elevations 30 to at least 20 ft (MW-13 and B-27); see Section C and D (Figures 3-11 and 3-12). Its lateral extent is unknown but it is presumed to underlie the northwest portion of the property to the original shoreline as well as the cooling pond.

# 3.5.5 STRATIGRAPHIC UNITS OF THE STACK AREA

The geologic system of the Stack Area consists of a thin veneer of Granular Fill underlain by a thick sequence of Vashon Advance deposits. The Vashon Advance deposits consist of a thick sequence of clayey, silt with thin interbeds of silty fine sand. Figures 3-9 and 3-10 illustrate the stratigraphy within the Stack Area.

The geologic units of the Stack Area consist of the following:

- Vashon Advance Sands (Qva)
- · Vashon Advance Silt (Qvs).

# 3.5.5.1 Vashon Advance Sands (Qva)

The Vashon Advance Sands are present directly below the granular fill material and interbedded with Vashon Advance Silt. Three layers of Vashon Advance Sand have been identified and are referred to as Vashon Advance Sand 1 to 3.

#### Vashon Advance

Vashon Advance Sand 1 occurs directly below the Granular Fill on the Stack hill. It is present at elevations above 135 ft within the Stack Area. It is composed of 8 to 10 ft of medium dense, brown, silty, fine sand to dense, brown, fine sand.

Vashon Advance Sand 2 is a very dense, gray, fine sand. The unit is about 5 ft thick and was identified in well B-19. Surface exposures of this unit are marked by a spring on the access road east of the stack at elevation 120 ft (Figure 3-6).

Vashon Advance Sand 3 is an 8- to 10-ft-thick layer of gray, silty to very silty, fine sand to very sandy silt. It was encountered in wells B-17, B-18 and B-31 and was found at about elevation 100 to 90 ft. The surface exposure of this unit is marked by a series of seeps identified by slump scarps in the hillside of the gully east of the stack at about elevation 100 ft.

# 3.5.5.2 Vashon Advance Silt (Qvs)

The Vashon Advance Silt consists of a thick sequence of uniform hard, gray, laminated silt with varying amounts of fine sand and clay. The Vashon Advance Silt is the most extensive geologic material on the site. It is present at elevation 140 ft (B-18) on top of the Stack Hill and at elevation -65 within the Plant Area in boring B-15.

The Vashon Advance Silt is an effective aquitard on the site.

#### 3.6 GROUNDWATER

#### 3.6.1 INTRODUCTION

The groundwater flow characteristics of the Asarco site are discussed in the context of the three geographic areas defined in Section 3.5 (see Figure 3-18). Groundwater occurs in one or more relatively permeable water-bearing geologic units within these areas.

Of the geologic units identified in Section 3.5, those that exhibit similar hydraulic (water-carrying) behavior are referred to as hydrogeologic units. The relationship between geologic and hydrogeologic units is shown in Figure 3-7. The term "aquifer" is used to designate a water-bearing hydrogeologic units, while the term "aquitard" is used to distinguish a lower permeability unit between aquifers. These terms, used in this manner, are terms of convenience used to describe hydrogeologic units. They are not intended to reflect the productivity or use of a hydrogeologic unit for water supply purposes.

A summary of the Groundwater section is presented in Section 3.6.2. A detailed discussion of the groundwater of the site is found in Sections 3.6.3 through 3.6.5.

Appendix B contains details of the field data exploration program. This includes details of borehole drilling, sub-surface soil sampling, well construction, groundwater sampling, hydraulic conductivity testing, and water level measurements. Boring logs and well construction diagrams are also found in Appendix B. Appendix D contains details of the laboratory testing program for subsurface soils. Appendix E presents groundwater elevation and precipitation graphs.

# 3.6.2 SUMMARY OF GROUNDWATER FLOW CHARACTERISTICS AT THE ASARCO SITE

#### 3.6.2.1 Plant Area

The Fill Aquifer within Plant Area contains the primary groundwater migration pathway for chemical contaminants entering Commencement Bay. Understanding groundwater flow characteristics and recharge sources for the Fill Aquifer helps assess the nature of the chemical loading to Commencement Bay. The Plant Area groundwater flow consists of the following:

- Three hydrogeologic units are identified within the Plant Area. They are termed the Fill Aquifer, Vashon Advance/Marine Silt Aquitard, and Pre-Vashon Sand Aquifer. The Fill Aquifer is the most extensive water-bearing zone beneath the plant area. The Fill Aquifer and the Pre-Vashon Aquifer are separated by a competent aquitard, the Vashon Advance/Marine Silt Aquitard. The Pre-Vashon Aquifer is not significant with respect to the migration of contaminants to the Bay.
- The Fill Aquifer consists of slag Fill, granular fill, alluvium, and native beach deposits. The Vashon Advance / Marine Silt Aquitard consists of sandy, clayey silt. The Pre-Vashon Sand Aquifer consists of clayey, very silty sand to silty, gravelly sand.
- The Fill Aquifer is an unconfined aquifer. Because of the varying tides, the groundwater gradient is constantly changing. The groundwater gradient during low tide is double that of intermediate tide. During high tide, the groundwater gradient reverses and inflow from Commencement Bay occurs. However, the net groundwater flow direction, gradient, and discharge from the site is toward Commencement Bay. There is an upward groundwater gradient within the Fill Aquifer and also between the Pre-Vashon Sand Aquifer and the Fill Aquifer.
- The calculated groundwater discharge over a tidal cycle based on groundwater level elevations measured November 10, 1988 is about 0.03 gpm/ft of shoreline. This equates about 105 gpm along 3,150 ft of the plant area fronting Commencement Bay.
- Recharge to the Fill Aquifer occurs from direct infiltration of precipitation to uncovered fill soils, flow from the cooling pond, loss of water from storm drains, and transfer of water from the regional aquifer northwest of the site.
- Groundwater within the Fill Aquifer moves along the following pathways (Figures 3-19 and 3-20):
  - Water within the Fill Aquifer migrates toward Commencement Bay
  - From the cooling pond into the Fill Aquifer water moves toward Commencement Bay
  - As interflow (perched water) moves within the Granular Fill in the Arsenic Kitchens area into the Fill Aquifer during rainy periods
  - From the storm drains water moves into the Fill Aquifer
  - From the regional aquifer up-gradient of the Parking Lot Area water moves into the Fill Aquifer.

# 3.6.2.2 Parking Lot Area

Water within the Parking Lot Area originates in off-site, upgradient regional sources and recharges the Fill Aquifer. The parking lot area groundwater flow consists of the following:

- Two hydrogeologic units have been identified within the Parking Lot Area: (1) the Glacial Drift Sequence and (2) the Pre-Vashon Deposits.
- The Glacial Drift Sequence consists of glacially derived Vashon and Pre-Vashon deposits. The combined thickness of these units is about 50 ft. The occurrence of water in these deposits is seasonal and discontinuous. Two water-bearing zones are identified: (1) a zone within the Vashon Advance and Vashon Till that saturates during the winter rainy season and (2) a water-bearing zone perched on a silt and lignite layer.
- Beneath the Glacial Drift Sequence are water-bearing soils within the lower Pre-Vashon deposits. These soils are hydraulically connected to the Fill Aquifer within the Plant Area.
- Groundwater in the Glacial Drift Sequence appears to move in the direction of the north end of the cooling pond and into the Fill Aquifer. Groundwater within the Pre-Vashon Gravel moves into the Fill Aquifer.
- Recharge to the Parking Lot area is from infiltration of precipitation within the upland areas to the west. Within the Fill Aquifer, recharge also originates from the regional aquifer to the west.

#### 3.6.2.3 Stack Area

The presence of a thick sequence of Vashon Advance Silt at shallow depths restricts the migration of groundwater from shallow water-bearing zones into deeper aquifers. The principal groundwater migration pathway within the Stack Area is within the near surface soils of the Granular Fill and Vashon Advance Outwash Sand 1. Deeper aquifers within the stack area are recharged off site and discharge through seeps into adjacent gullies. The deeper aquifers are not hydraulically connected to the Fill Aquifer. Therefore, a groundwater migration pathway to the Fill Aquifer is not likely. The stack area groundwater flow consists of the following:

- The hydrogeologic units of the Stack Area consist of a thin mantle of Granular Fill and Vashon Advance Outwash Sand that contains an unconfined aquifer. This aquifer overlies a thick deposit of lacustrine-derived sandy, clayey silt which behaves as an aquitard by restricting water flow and is termed the Vashon Advance Aquitard. Interbedded within the Vashon Advance Silt are thin beds of silty sand that are water bearing and are termed the Vashon Advance Sand 2 and 3 Aquifers. These aquifers are confined.
- An interflow zone appears to exist within the Granular Fill deposits on the hill from the Arsenic Kitchens area to the stack. This interflow zone becomes saturated during storm events and drains to the tunnels, retaining walls, and, likely, the Fill Aquifer at the site's original shoreline location.

- Based on the geologic framework, groundwater elevations, and topographic relief of the Stack Area, aquifers within the Stack Area exhibit similar flow characteristics:
  - Groundwater flow follows the topographic slope until it reaches the ground surface.

- Discharge occurs into the adjacent gullies by way of seeps.

- There is a downward gradient between the Vashon Advance Sand 1 Aquifer and deeper aquifers.
- Minimal transfer of flow occurs between the Vashon Advance Sand 1 Aquifer and deeper aquifers due to the low water-bearing capacity of the Vashon Advance Silt Aquitard.
- There are low groundwater flow velocities and small discharge volumes.
- Recharge to the upper aquifers within the Stack Area occurs from infiltration of
  precipitation on site to Granular Fill and Vashon Advance Outwash deposits.
  Recharge to the deeper aquifers occurs from precipitation infiltrating the upland
  areas to the west.
- Groundwater pathways within the Stack Area are the following (Figure 3-22):
  - Water infiltrating on top and at higher elevations of the stack encounters the Vashon Advance Silt Aquitard, flows laterally, and discharges in adjacent gullies as seeps.
  - Water entering the surface soil on the hillslope above the Arsenic Kitchens encounters the Vashon Advance Silt Aquitard and moves as interflow (perched water) until it discharges in the tunnels, through retaining walls, into gullies (for example, adjacent to MW-12), and the Fill Aquifer.
  - Water within the deeper confined aquifers is recharged in the uplands to the west, moves laterally, and discharges in the gullies and cliff faces adjacent to the stack.

A detailed discussion of the hydrogeology of the site follows in Sections 3.6.3 through 3.6.5.

#### 3.6.3 GROUNDWATER FLOW WITHIN THE PLANT AREA

# 3.6.3.1 Hydrogeologic Units of the Plant Area

Based on the site geologic data, three hydrogeologic units have been identified within the Plant Area. These are shown on Figures 3-19 to 3-21 and include:

- Fill Aquifer
- Vashon Advance/Marine Silt Aquitard
- Pre-Vashon Sand Aquifer.

### Fill Aquifer

The Fill Aquifer consists of water-bearing soils of the Granular Slag and Wood Waste artificial Fills, Alluvium, and Recent Marine Gravel units. These units appear to act as a single water-bearing zone in terms of flow of groundwater within the Fill Aquifer.

The total thickness of the Fill Aquifer ranges from 30 to 35 ft along the original shoreline to about 45 ft at the present shoreline. The bulk of this aquifer consists of granular-to-massive fractured Slag Fill which underlies the eastern half of the site (approximately from the original shoreline to the present shoreline).

The composition of the Fill Aquifer changes towards the original shoreline. In the vicinity of wells MW-4, MW-5 and B-27, the fill aquifer extends into glacial drift deposits and Pre-Vashon Gravel (Figure 3-21). This is based on similar water levels in well B-27 and wells screened in the Fill Aquifer. The Pre-Vashon Gravel is likely connected to the regional aquifer on the Point Defiance peninsula.

Between the plant administrative offices and well B-23, the Fill Aquifer consists of Alluvium overlain by 10 to 20 ft of Granular Fill. In this area, the Fill Aquifer appears to extend west into granular fill and alluvial materials beneath the cooling pond (Figure 3-20).

Between the Plant and the Stack areas (Figure 3-18), the lateral extent of the fill aquifer roughly coincides with the geologic boundary between the Vashon Advance Silt and the Granular Fill (approximately the original shoreline boundary). It appears that this boundary represents a no-flow boundary for the Fill Aquifer. Here, the Fill Aquifer pinches out against the Vashon Advance Silt unit.

Southeast of the Arsenic Kitchen area near wells MW-8 and MW-9, the fill aquifer consists of about 15 ft of Slag Fill underlain by about 10 ft of Recent Marine Gravel. Although no borehole control exists southwest of MW-9, it is assumed that the Fill Aquifer pinches out against the Vashon Advance Silt along the escarpment to the west.

#### Vashon Advance Silt Aquitard

Low permeability Vashon Advance Silt separates the Fill Aquifer from the deeper Pre-Vashon Sand Aquifer. The thickness of this unit is about 25 ft near wells B-14 and MW-2C2. This aquitard thickens toward the southeast to over 55 ft at boring B-15 (Figure 3-15). Based on the low vertical hydraulic conductivity and thickness of this material, this unit isolates the Fill Aquifer from deeper aquifers.

## Pre-Vashon Sand Aquifer

The Pre-Vashon Sand Aquifer consists of a 10-ft-thick unit of very silty sand that grades to a silty gravelly sand. This is a confined aquifer having a water level elevation of about 20 ft. This aquifer pinches out toward the southeast end of the site as it was not encountered in boring B-15. Its southwestern extent is unknown.

# 3.6.2.2 Hydraulic Conductivity of the Plant Area

## Fill Aquifer

Twenty in-situ hydraulic conductivity tests were conducted in wells screened within the Fill Aquifer. Table 3-1 presents the results of this testing. The values ranged from  $6x10^{-3}$  to  $1x10^{-2}$  with a geometric mean of  $1.6x10^{-3}$ .

The hydraulic conductivity of the Recent Marine Sand is about 2 orders of magnitude smaller than that of the Slag Fill. These values ranged from  $2x10^{-2}$  to  $3x10^{-4}$  with a geometric mean of  $2.4x10^{-4}$ . This difference in hydraulic conductivity is likely due to the fine grained and well-sorted character of the beach sand deposits of the Recent Marine Sand as compared to the Slag Fill.

### Vashon Advance Silt Aquitard

Four, flexible-wall laboratory hydraulic conductivity tests were performed on relatively undisturbed samples collected in wells MW-2C2, MW-8, B-14, and B-16. The calculated vertical hydraulic conductivity values range from  $3.4x10^{-8}$  to  $1.8x10^{-6}$  cm/sec with a geometric mean of  $2.17x10^{-7}$ . Table 3-2 presents the results of the laboratory hydraulic conductivity testing.

These low values of hydraulic conductivity, thickness, and upward gradient (see Section 3.6.3.4, Groundwater Flow Directions and Gradients) between the Pre-Vashon Sand and the Fill Aquifer should effectively prevent groundwater flow from the Fill Aquifer to deeper aquifers.

## Pre-Vashon Sand Aquifer

One in-situ hydraulic conductivity test was performed in the Lower Aquifer in well B14. The calculated value was  $2 \times 10^{-4}$ .

## 3.6.3.3 Depth to Groundwater

#### Fill Aquifer

Depth to water was measured to obtain water level elevation data to assess groundwater flow characteristics. This data is presented in Appendix B (Tables B-4 and B-5). Wells MW-2A, MW-2B, MW-6, and MW-8 were monitored continuously using pressure transducers and data loggers for approximately 6 days between December 17 to 23,

Table 3-1. Summary of Hydraulic Conductivity (K) Estimates Based on Grain Size Distribution and Slug Testing

PLANT A	REA					
Well/ Boring Number	Sample Number	Sample Description	Representative Aquifer (Geo- logic Unit)	K-Estimate Grain Size	s in cm/sec Slug Test	Best Estimate
MW-1A			Fill Aquifer (Slag Fill)		2x10 <sup>-2</sup>	2x10 <sup>-2</sup>
MW-1B			Fill Aquifer (Slag Fill)	<u>-</u>	3x10 <sup>-2</sup>	. 3x10 <sup>-2</sup>
MW-2A			Fill Aquifer (Slag Fill/ Recent Marine Sand)		2x10 <sup>-2</sup>	2x10 <sup>-2</sup>
MW-2B			Fill Aquifer (Slag Fill)		2x10 <sup>-2</sup>	2x10 <sup>-2</sup>
MW-3A			Fill Aquifer (Slag Fill)	***	3x10 <sup>-2</sup>	3x10 <sup>-2</sup>
MW-4	S-7	Slightly silty, very sandy GRAVEL	Fill Aquifer (Pre-Vashon Outwash)	6.0x10 <sup>-3</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>
MW-4	S-10	Slightly gravelly, slightly silty, fine to medium SAND	Fill Aquifer (Pre-Vashon Outwash)	8.1x10 <sup>-3</sup>		
MW-5	S-12	Slightly silty, very sandy GRAVEL	Fill Aquifer (Pre-Vashon Outwash)	4x10 <sup>-2</sup>	2x10 <sup>-3</sup>	2x10 <sup>-3</sup>
MW-6	S-13A	Silty, sandy GRAVEL	Fill Aquifer (Recent Marine Sand)	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>
MW-8	S-9	Slightly silty, gravelly SAND	Fill Aquifer (Recent Marine Sand)	6.4x10 <sup>-3</sup>	1x10 <sup>-2</sup>	1x10 <sup>-2</sup>
MW-8	S-11	Very sandy GRAVEL	Fill Aquifer (Recent Marine Sand)	4x10 <sup>-2</sup>		

Table 3-1. Summary of Hydraulic Conductivity (K) Estimates Based on Grain Size Distribution and Slug Testing (continued).

PL	ANT	AREA	1	continu	ied)
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Well/ Boring Number	Sample Number	Sample Description	Representative Aquifer (Geo- logic Unit)	K-Estimate Grain Size	es in cm/sec Slug Test	Best Estimate
MW-9	S-6	Slightly silty, gravelly SAND	Fill Aquifer (Slag Fill/ Recent Marine Sand)	7.2x10 <sup>-3</sup>	3x10 <sup>-3</sup>	3x10 <sup>-3</sup>
MW-12	S-16	Slightly silty, very gravelly SAND	Fill Aquifer (Alluvium)	2.5x10 <sup>-2</sup>	6x10 <sup>-3</sup>	6x10 <sup>-3</sup>
B-16	S-6	Slightly silty, fine SAND	Fill Aquifer (Recent Marine Sand)	3x10 <sup>-3</sup>	2x10 <sup>-3</sup>	2x10 <sup>-3</sup>
B-33			Fill Aquifer (Slag Fill)		1x10 <sup>-2</sup>	1x10 <sup>-2</sup>
B-34		·	Fill Aquifer (Slag Fill)		2x10 <sup>-2</sup>	2x10 <sup>-2</sup>
B-35	S-9	Silty fine SAND	Fill Aquifer (Recent Marine Sand)	2x10 <sup>-3</sup>	3x10 <sup>-4</sup>	3x10 <sup>-4</sup>
B-36			Fill Aquifer (Slag Fill)		6x10 <sup>-3</sup>	6x10 <sup>-3</sup>
B-37		•••	Fill Aquifer (Slag Fill)		1x10 <sup>-2</sup>	1x10 <sup>-2</sup>
STACK AF	REA					
MW-11	S-7	Slightly clayey, sandy SILT	Vashon Aquifer (Vashon Advance Outwash)	2.5x10 <sup>-5</sup>		
B-18		Sandy SILT	Vashon Advance Sand 3		2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
B-19		Very silty, fine SAND	Vashon Advance Sand 3		1x10 <sup>-3</sup>	1x10 <sup>-3</sup>
PARKING	LOT AREA					
B-27		Very silty, fine SAND	Fill Aquifer (Ruston Gravel)		1x10 <sup>-4</sup>	1x10 <sup>-4</sup>
			3-19			

Table 3-1. Summary of Hydraulic Conductivity (K) Estimates Based on Grain Size Distribution and Slug Testing (continued)

### PARKING LOT AREA (continued)

Well/ Boring Number	Sample Number	Sample Description	Representative Aquifer (Geo- logic Unit)	K-Estimate Grain Size	es in cm/sec Slug Test	Best Estimate
MW-13	S-23	Slightly silty, gravelly SAND	Glacial Drift Sequence (Point Defiance Unit)	1.9x10 <sup>-2</sup>	4x10 <sup>-3</sup>	4x10 <sup>-3</sup>

Notes: 1) Sample description is based on the grain size distribution as observed in the Hart Crowser Soil Laboratory.

- 2) Best estimate is our best judgement of the most representative value comparing the two methods.
- 3) K-estimate based on GS is computed using  $K = (d_{10})2$  where  $d_{10}$  is the grain size for which 90 percent of soil will retain on the sieve and is given in millimeters.
- 4) See appendices for details of GS and Slug Test methods.

Table 3-2. Summary of Hydraulic Conductivity (K) Estimates Based on Laboratory K-Testing

Well/Boring Number	Sample Number	Representative Description	Geologic Unit	K-Estimate in cm/sec
MW-2C2	S-11	Wet silt with trace of sand lens	Commencement Silt	3.3x10 <sup>-7</sup>
MW-8	S-14	Wet SILT	Commencement Silt	1.1x10 <sup>-7</sup>
MW-10	S-8	Wet sandy SILT	Weathered Commencement Silt	1.1x10 <sup>-6</sup>
B-14	S-14	Slightly sandy, slightly clayey SILT	Commencement Silt	1.8x10 <sup>-6</sup>
B-16	S-8	Very clayey SILT	Commencement Silt	3.4x10 <sup>-8</sup>
B-18	S-6	Slightly sandy, Clayey SILT	Commencement Silt	1.3x10 <sup>-7</sup>
B-23R	***	Clayey SILT	Commencement Silt	8 x10 <sup>-8</sup>
B-25R	S-1	Very Clayey SILT	Commencement Silt	6 x10 <sup>-8</sup>

Notes: 1) Sample description is based on the visual observations made by Hart Crowser Laboratory Manager per ASTM D 2488.

2) See appendices for details of the laboratory procedures.

The Fill Aquifer is a water table aquifer. The water table is influenced by Commencement Bay tides. Water level data indicate that wells completed within the Slag fill fluctuate coincidently with the tides with a slight damping effect and a lag time of about 2 to 3.5 hours. The influence of tidal fluctuation on the water table in the Fill Aquifer decreases in the inland direction as indicated by water level response to the tides in well MW-6 (Figure 3-23). This is a result of both distance from the shoreline and the hydraulic conductivity of the fill.

The depth to water for wells screened within the Fill Aquifer, under average tidal conditions, varies between 6 to 28 ft below the ground surface. Seasonal precipitation causes the water table to fluctuate 0.5 to 3 ft throughout the year (see Appendix E).

The granular fill materials near well B-23 are unsaturated. Well B-23 did not show water during groundwater level monitoring during the fall and winter of 1988/89.

### Pre-Vashon Sand Aquifer

The Pre-Vashon Sand Aquifer is a confined aquifer. Well B-14 is the only well screened in this aquifer. The depth to water in B-14 is approximately 10 ft below ground surface and fluctuates about 0.5 ft diurnally due to tidal loading of the overlying soils.

### 3.6.3.4 Groundwater Flow Directions and Gradients

# Fill Aquifer

The groundwater (water table) elevation contour maps for the Fill Aquifer are presented on Figures 3-24 through 3-26. These maps were constructed using data collected during low, intermediate, and high tidal conditions November 10, 1988. These contours are based on the linear interpolations of water level elevations between wells.

<u>Tidal Effects</u>. The overall net groundwater flow direction and discharge is into Commencement Bay. Due to tidal action, the groundwater gradient and discharge volume is constantly changing. Groundwater elevation contour maps (Figures 3-24 and 3-25) show that, during low and intermediate tide conditions, the horizontal groundwater gradient is toward Commencement Bay. The average estimated horizontal gradients of the Fill Aquifer during low and intermediate tide conditions are about 0.02 and 0.01 respectively.

During high tide, the groundwater gradient reverses and flows inward from Commencement Bay (Figure 3-26). The average horizontal gradient during the reverse gradient condition is about 0.005 to 0.01. Based on continuous water level monitoring for November 14 to 17, 1988 this gradient reversal occurs approximately 6 hours over the monitored tidal cycle. The water elevation contour maps also indicate that a zone of reverse gradient zone extends about 200 to 300 ft inland from the present shoreline. During the reversed gradient condition, groundwater does not discharge into Commencement Bay.

<u>Vertical Gradients</u>. Groundwater elevation data indicate that an upward vertical gradient exists within the Fill Aquifer. The water levels in MW-2A, screened in the bottom of the Fill Aquifer, are generally higher than the water level elevations of MW-2B, which is screened in the upper portion of the Slag Fill. This is also the case with wells B-35 (screened in the Recent Marine Sand) and nearby wells B-34, B-33, and B-36 (screened in the Slag Fill).

An upward gradient of about 0.18 ft/ft exists between the Pre-Vashon Sand Aquifer and the Fill Aquifer. This is based on the groundwater level in well B-14 being 5.4 ft above that of the lower portion of the Fill Aquifer (B-35) during low tidal conditions of November 10, 1988. Such upward gradients are common in the coastal areas of Puget Sound and restrict the downward migration of contaminants if present.

# 3.6.3.5 Recharge to the Plant Area

The source of recharge to the Fill Aquifer is an important variable in identifying sources of contaminants to the Fill Aquifer.

Based on the available data, recharge to the Fill Aquifer occurs through the following mechanisms:

- direct infiltration of precipitation to fill soils in areas not covered by buildings or pavement
- · migration of groundwater from the regional aquifer northwest of the site
- infiltration through soils adjacent to and downgradient of the cooling pond
- loss of water from storm drains crossing the site.

Most of the site is covered by either buildings or pavement. Hence, direct infiltration of precipitation is not the primary mechanism of recharge to the Fill Aquifer. However, certain areas of the Fill Aquifer show a marked increase in water levels associated with storms. This is the case with wells MW-12, MW-6 and MW-9. Water levels in these wells respond nearly coincidently with the timing of precipitation (Appendix E). This response indicates that recharge from precipitation on or very near the site is occurring.

The mechanisms for this on-site recharge are likely one or more of the following: (1) transfer of water from the interflow zone in the Arsenic Kitchen area to the Fill Aquifer at the original shoreline location; (2) loss of water to the Fill Aquifer from storm drains that transect the site (See Surface Water, Section 3.3), and (3) infiltration of precipitation to soils within and around the cooling pond.

Recharge to the Fill Aquifer also occurs from the regional aquifer within the glacial and pre-glacial soils in the Parking Lot Area and in the uplands to the west. This is based on two observations. First, water-bearing soils of the Pre-Vashon deposits are found adjacent to deposits of the Fill Aquifer (Figure 3-21). And second, similar water level elevations are found in well B-27 (screened in the Pre-Vashon Gravel) and wells screened in the Fill Aquifer (MW-4, MW-5, MW-6, and MW-12 etc., Figures 3-24 to 3-26)

Recharge to the Fill Aquifer could be occurring from water filtrating the soils adjacent to the cooling pond. This assumption is based on water table elevations of MW-12, B-27, and MW-5 and the apparent continuity of alluvial soils from MW-12 toward the cooling pond.

Recharge to the Pre-Vashon Sand Aquifer from the Fill Aquifer is unlikely. This assumption is based on the upward gradient between the Pre-Vashon Sand Aquifer and the Fill Aquifer, the thickness and vertical hydraulic conductivity of the Vashon Advance/Marine Silt Aquitard.

## 3.6.3.6 Groundwater Flow Pathways

Groundwater Flow Pathways for the Plant Area are illustrated in Figures 3-19 to 3-21. They are as follows:

- The main groundwater flow path within the Fill Aquifer is generally toward Commencement Bay. Water entering the Fill Aquifer will discharge into Commencement Bay.
- A groundwater flow path may exist from the cooling pond into the fill aquifer.
- A groundwater flow path exists from the glacial and pre-glacial soils of the Parking Lot area and in the uplands to the west.
- A groundwater flow path may exist from the interflow zone adjacent to the Arsenic Kitchens area to the Fill Aquifer at the original shoreline location.
- · A groundwater flow path exists from the storm drains into the fill aquifer.

No hydraulic connection is known to exist from the deeper aquifers beneath the Stack Area to the Fill Aquifer. This is based on the pinching out of deposits that comprise the Fill Aquifer against the Vashon Advance Silt unit. Likely, the Pre-Vashon Sand unit extends under the stack hill and could be receiving recharge from upland areas to the southwest.

# 3.6.3.7 Groundwater Discharge to Commencement Bay

Groundwater discharge and velocity within the Fill Aquifer were calculated for low, intermediate, and high tide for three regions on the site. Darcy's Law was used to calculate the discharge and velocity of groundwater within three regions of the site as shown in Figures 3-24 to 3-26. An equivalent hydraulic conductivity of .01 cm/sec was used for the Fill Aquifer. Groundwater discharge calculations are based on continuous water level monitoring data during November 14 to 17, 1988 (Figure 3-22). Hand measurements of water levels in Plant Area wells were made during highest high, intermediate, and lowest low tide on November 10 to 11, 1988.

The net groundwater flow over a 24-hr period is toward Commencement Bay. Outflow to the bay occurs about 18 hours of the day based on continuous water level monitoring. The net discharge of water to Commencement Bay over a tidal cycle is approximately 0.03 gpm/ft of shoreline reach. This equates to 105 gpm along 3,150 ft of the Plant Area that fronts Commencement Bay. These ranges represent a time weighted average of the discharge during highest high, intermediate, and lowest low tides. The discharge for lowest low tide is about 280 gpm; for intermediate tide it is about 130 gpm. For highest high tide, the inflow to the Fill Aquifer is about 140 gpm.

### 3.6.4 HYDROGEOLOGY OF THE PARKING LOT AREA

Water within the Parking Lot Area originates in off-site, upgradient regional sources and recharges the Fill Aquifer.

## 3.6.4.1 Hydrogeologic Units of the Parking Lot Area

Based on the site geologic data, two hydrogeologic units have been identified within the Parking Lot Area (Figure 3-21). These are the following:

- Glacial Drift Sequence
- Fill Aquifer.

## Glacial Drift Sequence

The Glacial Drift Sequence consists of unsaturated and water-bearing soils of the Vashon Advance, Vashon Till, Vashon Outwash, Pre-Vashon Till, Pre-Vashon Outwash and Pre-Vashon Silt. The combined thickness of these units is about 50 ft. Because the presence of water within this sequence is discontinuous, it is not convenient to discuss this sequence in terms of aquifers and aquitards. However, two water-bearing zones have been identified within this sequence of soils.

The first water-bearing zone consists of soils of the Vashon Till and Vashon Advance soils. However, these soils bear water only during the winter rainy season.

The second water-bearing zone within the Glacial Drift Sequence exists as "perched water" within the lower portion of the Glacial Drift Sequence as monitored by wells MW-13 and B-29. The saturated thickness of this unit ranges from about 2 ft in well B-29 to 12 ft in well MW-13. It appears that water is perched on the thin layer of lignite and silt within the lower portion of the Glacial Drift Sequence.

The lower portion of the Glacial Drift Sequence (Pre-Vashon Sand, Silt, and Lignite) consists of lignite and silt. These soils encountered in wells MW-13 and B-29 appear to behave as an aquitard maintaining a thin saturated zone within gravelly sand units of the Pre-Vashon Sand, Silt, and Lignite geologic unit. This aquitard appears to pinch out to the southeast (toward the cooling pond).

### Pre-Vashon Deposits

Water-bearing soils of the lower portion of the Pre-Vashon Sand and Gravel (MW-5 and B-27) appear to be in hydraulic connection with the Plant Area Fill Aquifer. The thickness of these deposits were not defined within our investigation.

3.6.4.2 Hydraulic Conductivity of Hydrogeologic Units of the Parking Lot Area

## Glacial Drift Sequence

One in-situ hydraulic test was done in the perched zone of the Glacial Drift Sequence in well MW-13. The value of hydraulic conductivity calculated was  $4x10^{-3}$  cm/sec.

### Pre-Vashon Deposits

The hydraulic conductivity calculated for the Pre-Vashon Deposits at B-27 was 1x10<sup>-4</sup>. This value is the lowest value calculated for this deposit.

3.6.4.3 Depth to Groundwater and Groundwater Flow Directions

## Glacial Drift Sequence

Two water-bearing zones have been identified within this sequence of soils. Water level data taken from the middle of October through the last week of January 1989 indicate that the lower portion of the Vashon Advance and Vashon Till remain unsaturated during the dry season and saturate during the winter rainy season. Wells B-26, B-28 and, B-30 monitor this zone. Well B-28 remained dry until December 1, 1988 and Well B-30 remained dry until January 5, 1989. Well B-26 remained dry throughout the monitored period. Figure 3-27 shows the water level elevations for the Parking Lot Area wells.

The water depths in wells B-28 and B-30 were 31.6 and 34.2 ft (elevation 67.9 and 45.1 ft) respectively on January 24, 1988. It is not practical to quantitatively determine a groundwater flow direction because water in this zone is discontinuous. However, water in this zone likely follows the topographic slope toward the plant offices.

The water depths in the perched zone in wells MW-13 and B-29 are about 47 and 42 ft respectively. The perched zone appears to be sensitive to recharge from precipitation infiltrating upland areas to the north and west. The water level in well MW-13 varies about 0.8 ft in response to precipitation. Although the summer water level in MW-13 is about 1 ft lower than during the winter months, the water level in B-29 remained relatively constant over the monitoring period.

Based on the water elevations of wells B-29 and MW-13, the groundwater flow direction of the perched zone appears to be toward the south (toward the cooling pond). Figure 3-27 shows the spot elevation of the groundwater elevation of the perched zone. During Phase I field investigations (September 1987 to January 1988), a seep was observed in

the hillslope southwest of well MW-4. It was not observed during Phase II (August 1988 to January 1989). This seep may indicate an easterly flow toward the hillslope west of the wells MW-4 and MW-5.

## Pre-Vashon Deposits

The depth to water in the Pre-Vashon Deposits near well B-27 is about 56 ft. The water level in B-27 varies about 1 ft (see Appendix E) in response to precipitation during the winter months. This variation is similar to wells on the western side of the plant in the wells screened in the Fill Aquifer (wells MW-4, MW-5, MW-12, MW-6, MW-8 and MW-9). This indicates that infiltration from precipitation on upland areas and perhaps the cooling pond provides a significant portion of the recharge to the fill aquifer.

Based on the water level elevation of wells B-27, MW-4, MW-5, and MW-12 the groundwater flow direction in the Parking Lot Area within the Pre-Vashon Deposits is toward Commencement Bay. This flow direction is consistent with the expected regional gradient and gradients observed within the Plant Area.

## 3.6.4.4 Recharge to the Parking Lot Area

## Glacial Drift Sequence

Water-bearing zones in the Glacial Drift Sequence receive recharge from precipitation in upland areas to the north and west of the Parking Lot Area. Water level response to precipitation in wells MW-13 and B-29 (Appendix B) suggests that the Glacial Drift Sequence receives the bulk of its water in the winter rainy season.

#### Fill Aquifer

The fill aquifer likely receives recharge from infiltration as well as recharge from upgradient water-bearing soils. Groundwater elevation data further suggests that a significant portion of the recharge to the Fill Aquifer is due to groundwater flow from the regional aquifer in glacial soils in upland areas to the north and west of the Asarco site. Water-level-verses-precipitation relationships (Appendix E) support the finding that infiltration from precipitation is also a likely source of recharge.

# 3.6.4.5 Groundwater Flow Pathways within the Parking Lot Area

Groundwater pathways within the Parking Lot area shown on Figure 3-21 are as follows:

- Infiltration of precipitation recharging the seasonally saturated and perched zones of the Glacial Drift sequence
- Lateral movement south in the perched zone toward the cooling pond. Downward movement into the Fill Aquifer where the Point Defiance aquitard pinches out

• Lateral movement originating within the regional aquifer to the west providing a source of recharge to the Pre-Vashon Sand and Gravel.

## 3.6.5 HYDROGEOLOGY OF THE STACK AREA

The groundwater pathway of importance within the Stack Area is in the near surface soils of the Granular Fill and Vashon Advance Sands. The presence of the thick sequence of Vashon Advance Silt found at shallow depths in the Stack Area prevents the migration of groundwater into deeper aquifers.

Deeper Vashon Advance Sand aquifers, identified in this investigation, are recharged off site and discharge through seeps into adjacent gullies. These deeper aquifers are not directly hydraulically connected to the Fill Aquifer. Figure 3-22 illustrates the hydrogeologic units and principle groundwater flow pathways in the Stack Area.

# 3.6.5.1 Hydrogeologic Units of the Stack Area

Based on the geologic and well data collected by Geolabs (1969 and 1970), the hydrogeologic units of the Stack Area consist of a thick deposit of lacustrine-derived sandy, clayey silt with thin interbeds of very fine silty to very silty sand. This sequence is to be part of the Vashon Advance deposits. The sand interbeds are water bearing and are referred to as Vashon Advance Sand Aquifers 1 through 3. The Vashon Advance Silt acts as an aquitard restricting the vertical transfer of water from one sand layer to another. Figure 3-22 illustrates the relationships between these units.

The hydrogeologic units in the Stack Area are as follows:

- Vashon Advance Sand 1 through 3
- Vashon Advance Silt Aquitards.

### Vashon Advance Sand 1 Aquifer

The Vashon Advance Sand 1 Aquifer consists of very-silty-to-silty sands of the Vashon Advance Outwash. This unit directly underlies the Granular Fill material on the top of the stack hill. Wells MW-11, B-20, B-21, and B-22 are screened in this unit. The thickness of this unit ranges from 10 ft at MW-11 to 4.5 ft at B-21. Wells MW-11 and B-22 have remained dry for the length of the project. Wells B-21 and B-20 have shown up to 1 to 1.5 ft of water during the water level monitoring of Phase II.

### Vashon Advance Silt Aquitards

The aquitards within the Stack Area consist of hard silt with minor amounts of sand and clay of the Vashon Advance Silt unit. The Vashon Advance Silt unit appears to be a continuous unit of lacustrine-derived silts with thin interbeds of silty to very silty sand. These sand interbeds are generally water-bearing and appear to be isolated from each other by the silt.

Near wells B-17 and B-18, the Vashon Advance Silt Aquitard has a thickness of 30 to 45 ft. Near well B-19 the Vashon Advance Silt Aquitard contains a 5-ft-thick sand layer representing the Vashon Advance Sand 2 Aquifer.

## Vashon Advance Sand 2 and 3 Aquifers

As discussed in Section 3.5, the sand interbeds identified on the site in the Vashon Advance Silt are termed Vashon Advance Sand 2 and 3. Since these units are water bearing, they are referred to as the Vashon Advance Sand 2 and 3 Aquifers.

The Vashon Advance Sand 2 consists of a thin interbed of silty fine sand. The Vashon Advance Sand 2 Aquifer is screened in well B-19 where it is about 5 ft thick. This aquifer is confined, showing a water level of about elevation 130 ft. This unit appears to pinch out toward the south and is composed of sand stringers in well B-18 and is not present at well B-17. Thus only one well was installed in the Vashon Advance Sand 2 Aquifer. This aquifer discharges a seep at elevation 120 ft on the access road east of the stack.

The Vashon Advance Sand 3 Aquifer consists of about a 10-ft-thick, interbedded, very-sandy-silt-to-very-silty sand. This aquifer is confined with a water level elevation at about 90 to 115 ft. This unit outcrops in the railroad tunnel cut and on the north and south hill sides of the Stack Hill at an elevation of about 85 to 95 ft. It most likely provides water that seeps in the railroad and car tunnels and in the gully south of the stack at about elevation 100 ft.

## 3.6.5.2 Hydraulic Conductivity of the Stack Area

## Vashon Advance 1 Aquifer

No in-situ hydraulic conductivity tests were performed in the Vashon Advance 1 Aquifer due to the dry wells or low water volumes in wells screened in this unit. However, two values of hydraulic conductivity were calculated based on the grain size distribution by the Hazen method (Freeze and Cherry 1979):  $2.5 \times 10^{-3}$  and  $2.5 \times 10^{-3}$  cm/sec. Because of the fine-grained nature of these soils, these values are considered estimates.

## Vashon Advance Silt Aquitards

One flexible-wall vertical hydraulic conductivity test was performed in the Hart Crowser soils laboratory on a relatively undisturbed sample obtained from well B-18 at a depth of 15 ft (elevation 136 ft). The calculated value of hydraulic conductivity was  $1.3 \times 10^{-7}$  cm/sec.

This value of hydraulic conductivity is similar to values measured in the plant area and appears to be representative of the hydraulic conductivity of the Vashon Advance Silt unit. This conclusion is based on the uniform nature of the Vashon Advance Silt across the site. It can be illustrated by grain size distribution (Appendix D), visual classification

(both field and laboratory), and the results of the laboratory hydraulic conductivity testing results of other Vashon Advance Silt soils.

A total of 8 laboratory vertical hydraulic conductivity tests were performed on the Vashon Advance Silt at various elevations. The calculated values range from 3.4x10<sup>-8</sup> to 1.1x10<sup>-6</sup> cm/sec with a geometric mean of 1.9x10<sup>-7</sup>. These values are presented in Table 3-2.

## 3.6.5.3 Depth to Groundwater, Groundwater Flow Directions

Figures 3-28 and 3-29 show interpreted water level elevations within the Vashon Advance 1 and 3 Aquifers. These aquifers exhibit similar groundwater flow characteristics. They include:

- Groundwater flow that follows the topographic slope until it reaches land surface
- Discharge into the adjacent gullies and gulches through seeps
- Low groundwater flow velocities and small discharge volumes compared to the Plant Area
- · Little or no migration of flow between aquifers
- No direct groundwater flow path from Vashon Advance 2 and 3 aquifers to the Fill Aquifer.

## Vashon Advance 1 Aquifer

The Vashon Aquifer is an unconfined aquifer. The water level elevations measured from our wells and interpreted from existing borings (Geolabs 1969, 1970) appear to follow the topographic slope until it intercepts the land surface, where it discharges as seeps into the adjacent gullies. The groundwater gradient within the Vashon Advance Outwash is about 0.1. The seep south of the stack at elevation 155 ft emanates from this aquifer.

Although four wells were installed within the Vashon Advance 1 Aquifer, only wells B-20 and B-21 have shown water. Groundwater discharge along the gully southwest of the stack and the foundations of the stack are thought to interrupt groundwater before wells MW-13 and B-22. The depth to water in wells B-20 and B-21 are 17 and 10 ft (elevation 130 and 143 ft) respectively.

A downward gradient exists from the Vashon Advance Sand 1 Aquifer to deeper aquifers in the Stack Area. A very small amount of water is thought to flow from the Vashon Advance Sand 1 Aquifer to deeper aquifers. This is based on the hydraulic conductivity and thickness of the Vashon Advance Silt and the discharge characteristics of the Vashon Advance Sand 1 Aquifer.

## Vashon Advance Sand 2 Aquifer

Well B-19 is the only well screened within the Vashon Advance Sand 2 Aquifer. This aquifer is confined and has a depth to water of about 16 ft (elevation 130 ft). This aquifer discharges water from a seep located in the road cut on the access road east of the stack at elevation 121 ft. The water level in well B-19 responds to seasonal precipitation and has increased about 1.5 ft since early November.

Areal distributed water level data are lacking to construct a groundwater flow map for this unit. This aquifer is thought to have similar characteristics to those described for all the Stack Area Aquifers.

## Vashon Advance 3 Aquifer

Wells B-17, B-18, and B-31 are completed in the Vashon Advance 3 Aquifer. Figure 3-28 is an interpreted groundwater flow map for this unit. The depth to water in wells B-17, B-18, and B-31 are about 63, 38, and 9 ft respectively. These are equivalent to elevations of 91, 115, and 92 ft respectively. The water levels in this aquifer respond to seasonal precipitation with a 1 to 3 ft variation (Appendix E).

Well B-31 (screened adjacent to and below the top of the railroad tunnel) has a higher water level variation than wells B-18 and B-17. Because this well is the most downgradient well within this unit, one would expect it to have a lower water level elevation than other wells screened in the Vashon Advance 3 Aquifer. However, its higher water level elevation is likely due to recharge of water from direct infiltration of precipitation to Granular Fill soils on top of and adjacent to the railroad tunnel. The higher water level may also be caused by water dammed behind the railroad and car tunnels.

Groundwater in the Vashon Advance 3 Aquifer generally follows the topographic slope until intersecting the ground surface in the gullies and cliffs above Commencement Bay. Discharge of this aquifer can be observed in seeps in the gully to the southeast of the stack hill at elevation 100 ft. The horizontal groundwater gradient near the stack is approximately 0.15.

There is no apparent connection of the Vashon Advance 3 Aquifer to other aquifers in the plant area. This conclusion is based on the elevation and groundwater discharge characteristic of this unit. However, other deeper aquifers interbedded with or below the Vashon Advance Silt may provide a source of recharge to the Fill Aquifer.

## 3.6.5.5 Recharge to the Stack Area

Recharge to the Vashon Advance 1 Aquifer occurs mostly as direct infiltration to surface soils adjacent to the stack and in the upland areas to the west. Recharge to the Vashon Advance 2 and 3 aquifers of the Stack Area occurs mostly from precipitation infiltrating the uplands area to the west. Water-level-verses-precipitation graphs (Appendix E) illustrate the relationship between winter rains and recharge to aquifers in the Stack Area.

Although deep aquifers in the Stack Area do not provide a direct source of recharge to the Fill Aquifer, runoff entering the storm drains from the gullies on either side of the stack may enter the Fill Aquifer. Water in the interflow zone may also enter the Fill Aquifer where the Commencement Silt pinches out against the Slag Fill at the original shoreline location.

## 3.6.5.6 Groundwater Migration Pathways in the Stack Area

Groundwater pathways in the Stack shown on Figure 3-22 are these routes:

- Water infiltrating on top and at higher elevations of the stack encounters the Vashon Advance Silt Aquitard, flows laterally and discharges in adjacent gullies as seeps.
- Water entering the surface soil on the hillslope above the Arsenic Kitchens encounters the Vashon Advance Silt Aquitard and moves as interflow (perched water) until it discharges in the tunnels, through retaining walls, into gullies (adjacent to MW-12) and the Fill Aquifer.
- Water in the deeper confined aquifers is recharged in the uplands to the west, moves laterally, and discharges in the gullies and cliff faces adjacent to the stack.

### 3.7 MARINE SEDIMENT

### 3.7.1 SURFACE SEDIMENT GRAIN SIZE

Results of the marine sediment grain size analysis are shown in Figures 3-30 through 3-33. See Volume 2 for tabulations of the numerical grain size data. The highest percentages of coarse sediment, gravel and coarse sand are located off the slag fill area. Mixed sediments containing coarse grain sizes are also located off the smelter docks and to the northwest of the smelter. A large percentage of the gravel and coarse sand found off the slag fill area (Figures 3-32 and 3-33) contained slag particles.

Medium sand was found in high percentage in the offshore areas from the smelter and to the northwest of the slag fill area (Figure 3-31). Visual observations of the sand particles in the area offshore from the smelter showed the substrate to be primarily clean sand containing no slag particles in the areas of highest percent medium sand. However, sand particles observed off the slag fill area did contain a low percentage of slag particles.

Fine sediment was found at most stations, but it occurred in highest percentage to the southeast of the smelter (Figure 3-32). Inshore sampling stations on transects 17 through 19 showed the highest percent fine material of all stations sampled. Visual observation of the larger particle sizes within the "fine" material category showed a low percentage of slag particles.

In summary, the sediments off shore from the Asarco site display a wide range of physical characteristics. The range goes from sub-areas of predominantly gravel and slag to sub-areas of predominantly fine material. The physical characteristics of the sediment have a strong influence on the type of biota present in the sediment. Additionally, the slag particles themselves are unique in their configuration, which includes many crevices and small holes. These features also increase the overall surface area of the slag which in turn also effects the type of biota that are present.

#### 3.7.2 PHYSICAL CHARACTERISTICS OF CORE SAMPLES

The physical characteristics of marine sediment core samples are listed in Table 3-3. The physical characteristics of each sample and the water depth were recorded when the samples were collected. The percent coarse fragments represent the amount of gravel (grain size >2.0 mm) in a sample after it was dried and weighed in the laboratory.

### 3.7.2.1 Station 10A Core

The sediment core at station 10A was primarily silt in the upper 0.5 m, had green-black color with a slight hydrogen sulfide (rotten egg) odor, and contained some wood chips and shells. The percentage of coarse fragments decreased with increasing depth. A light gray colored gravelly sand was found between 0.7 and 0.8 m.

#### 3.7.2.2 Station 10-1 Core

The station 10-1 core was gravelly sand in the upper 0.5 m and a brown colored fine sand with clay below 1.0 m. The upper 0.5 m was tan/gray to gray/black in color, had no odor, and consisted of approximately one-third gravel. Shells were observed in the upper 0.3 m of the sediment core.

#### 3.7.2.3 Station 7-2 Core

The sediment core at station 7-2 represents the substrate offshore from the slag peninsula created during the construction of the Tacoma Yacht Club. The station 7-2 core was uniformly black sand-sized slag particles from 0.02 to 0.9 m depth. The upper 2 cm were a brown/black sandy silt with only four percent coarse fragments. The sediment below 1 m depth was dark gray silty sand.

#### 3.7.2.4 Station 13-2.5

The upper 0.3 m of sediment at station 13-2.5 was black/gray colored sand having a slight petroleum odor. The sand layer was underlain with gray colored clayey silty gravel that had up to 72 percent coarse fragments.

Table 3-3. Physical characteristics of marine sediment core samples.

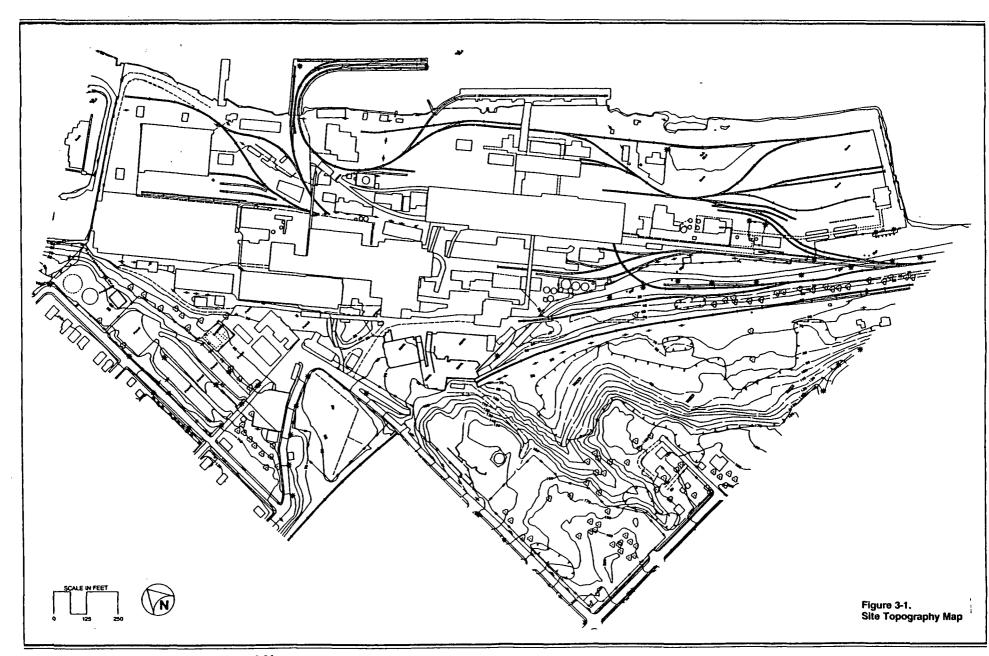
Sample I.D.	Sediment Depth (m)	Water Depth (m)	Sediment Principal	Type Secondary	Color	Odor	Debris	Coarse Fragments (%)
10A-01	0.0-0.1	10	silt	silt	black/green	slight H <sub>2</sub> S	wood/shells	22.7
10A-12	0.1-0.2	10	silt	silt	biack/green	slight H <sub>2</sub> S	wood/shells	18.8
10A-23	0.2-0.3	10	silt	silt	black/green	slight H <sub>2</sub> S	wood/shells	18.8
10A-34	0.3-0.4	10	silt	sand	black/green	none	wood/shells	12.8
10A-45	0.4-0.5	12	silt	sand	black	moderate H <sub>2</sub> S	shells	4.9
10A-78	0.7-0.8	12	sand	gravel	light gray	noné	shells	10.2
10-01	0.0-0.1	15	coarse sand	gravel	gray/black	none	shells/metal	35.1
10-12	0.1-0.2	15	coarse sand	gravel	gray/black	none	shells	39.5
10-23	0.2-0.3	15	coarse sand	gravei	gray	none	shells	40.3
10-34	0.3-0.4	15	medium sand	gravel	tan/gray	попе	none	31.8
10-45	0.4-0.5	15	medium sand	gravel	tan/gray	none	none	6.7
10-230	0.15-0.3	15	coarse sand	gravel	gray/black	none	shells	33.8
10-1015	1.0-1.5	15	fine sand	clay	tan	попе	none	14.3
7-2-01	0.0-0.1	24	silt	sand	brown/black	none	none	4.3
7-2-12	0.1-0.2	24	sand	sand	black	none	none	16.0
7-2-23	0.2-0.3	24	sand	sand	black	none	none	23.6
7-2-34	0.3-0.4	24	sand	sand	black	none	none	31.4
7-2-45	0.4-0.5	24	sand	sand	black	none	none	36.4
7-2-910B	0.9-1.0	21	sand	silt	black/gray	slight petroleum	none	29.9
7-2-1015	1.0-1.2	21	fine sand	silt	dark gray	none	none	11.8
Γ13-2.5-01	0.0-0.1	17	sand	sand	black/gray	slight petroleum	shells	13.3
Γ13-2.5-12	0.1-0.2	17	sand	sand	black/gray	none	shells	19.3
Γ13-2.5-23	0.2-0.3	17	sand	gravel	black/gray	slight petroleum	shells/wood	32.3
Γ13-2.5-34	0.3-0.4	17	gravel	silt	gray	none	shells	72.4
Γ13-2.5-45	0.4-0.5	17	gravel	clay	gray	попе	shells	54.8
Γ13-2.5-910	0.8-1.0	17	gravel	sand	gray/brown	none	none	35.7
6-0-01	0.0-0.1	18	silt	sand	black/brown	slight petroleum	wood	16.3
16-0-12	0.1-0.2	18	sand	silt	black	slight petroleum	none	8.7
16-0-23	0.2-0.3	18	sand	gravel	black	none	none	49.3
6-0-34	0.3-0.4	18	sand	sand	black/gray	strong H <sub>2</sub> S	wood	45.8
16-0-45	0.4-0.5	18	sand	silt	gray/black	slight H <sub>2</sub> S	shells	12.9
6-0-1012	1.0-1.2	18	silt	sand	gray	none	wood	24.9
2-01	0.0-0.1	28	silt	sand	black/gray	none	shells	15.6
-12	0.1-0.2	28	silt	clay	black/gray	none	shells	9.5
2-23	0.2-0.3	28	silt	sand	black	none	shells	12.3
-34	0.3-0.4	28	sand	gravel	gray/black	none	shelis	39.4
2-45	0.4-0.5	28	sand	sand	black	slight petroleum	shells	13.4
2-78	0.7-0.8	28	clav	gesvel	(reav		none	68.0
2-76 2-120	0.1-0.2	28 28	clay silt	gravel clay	gray black/gray	none	shells	16.9

## 3.7.2.5 Station 16-0

The sediment core at station 16-0 was black sandy silt in the upper 0.2 m and had a faint petroleum odor. The gray/black colored sand found between 0.3 and 0.5 m depth had a hydrogen sulfide odor. The sediment from 0.6 to 0.7 m depth was an odorless gray silty sand that contained shells. Below 1.0 m depth the sediment contained clay.

# 3.7.2.6 Station 2-1

The upper 0.3 m of sediment at station 2-1 was a grayish black sandy silt. Light gray colored clayey gravel was observed below 0.7 m depth.



3-36

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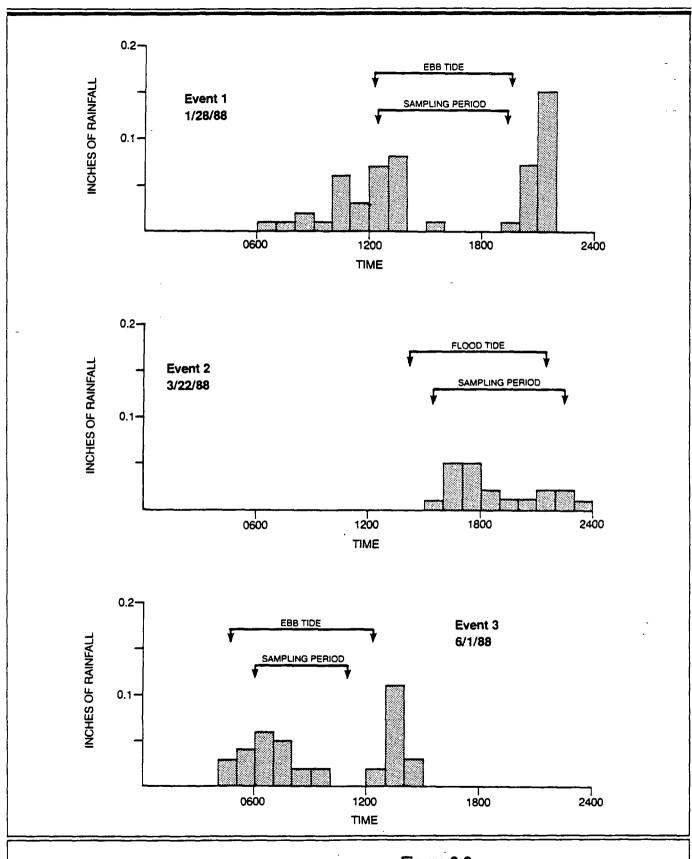


Figure 3-2. Hourly rainfall, sampling period and tidal movement for the three surface water monitoring events.

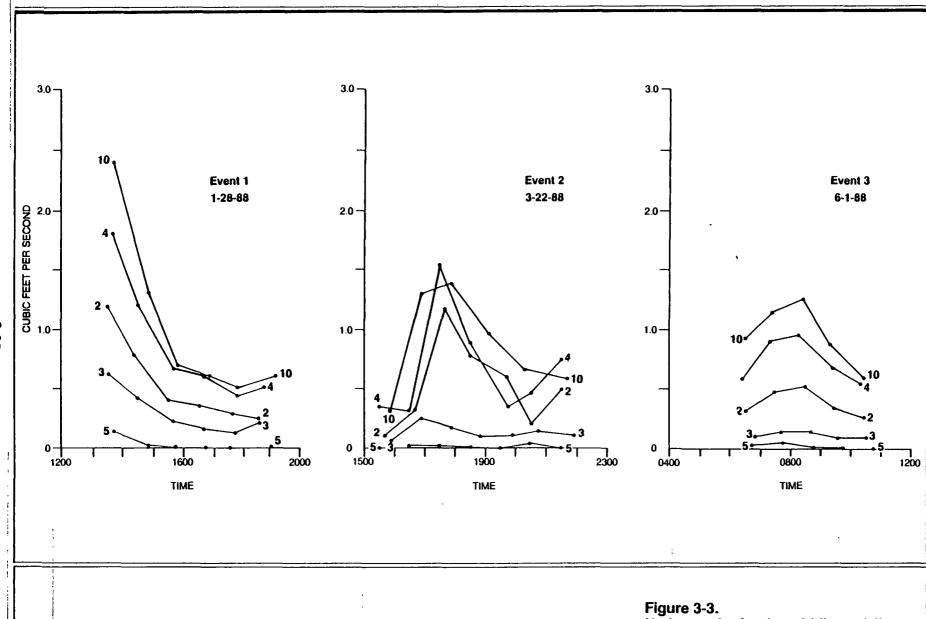
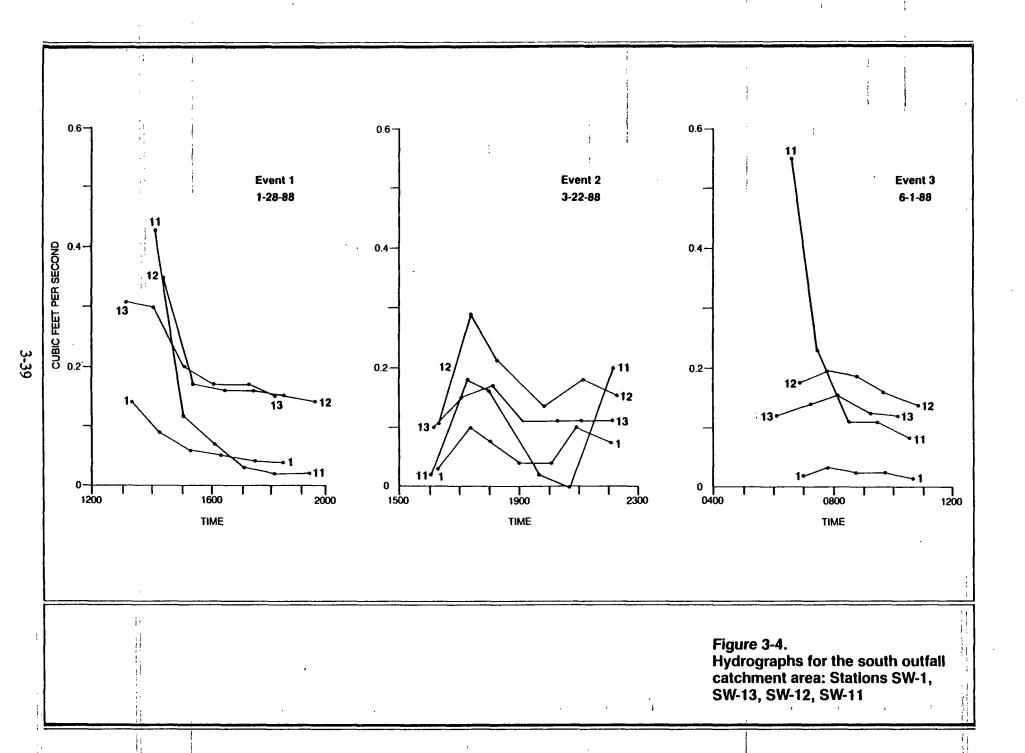
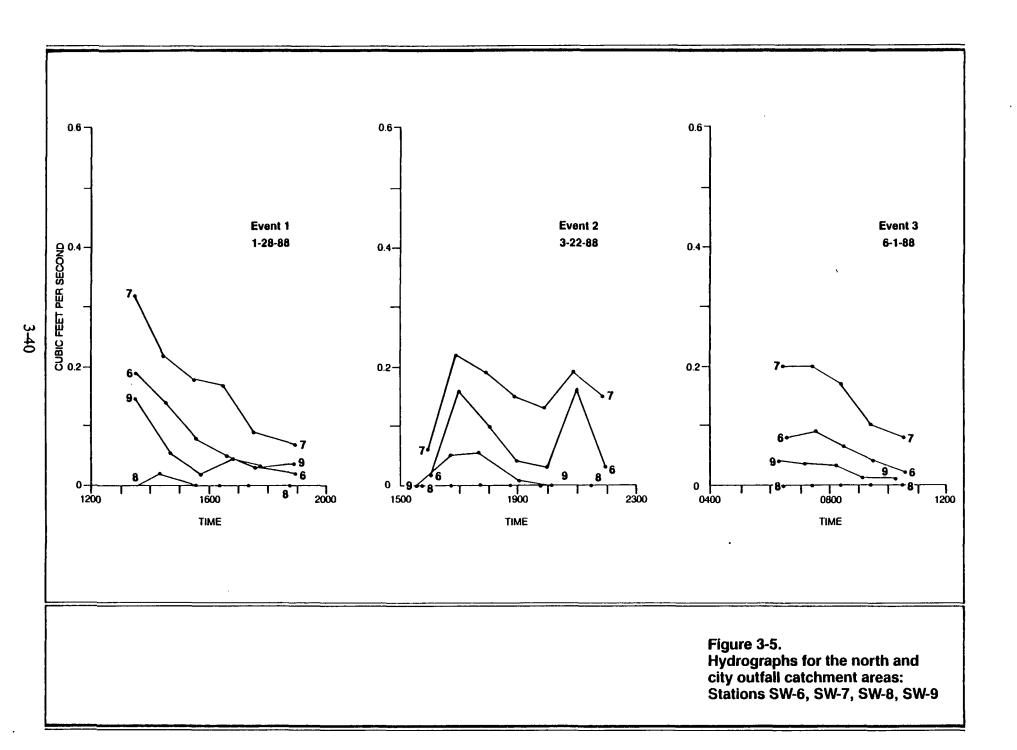
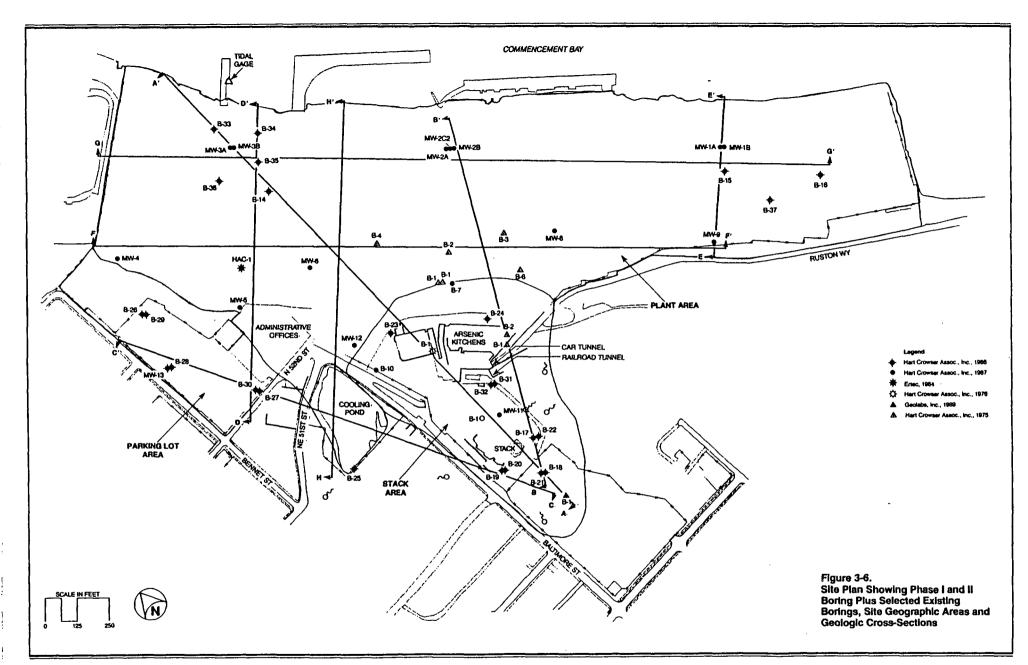
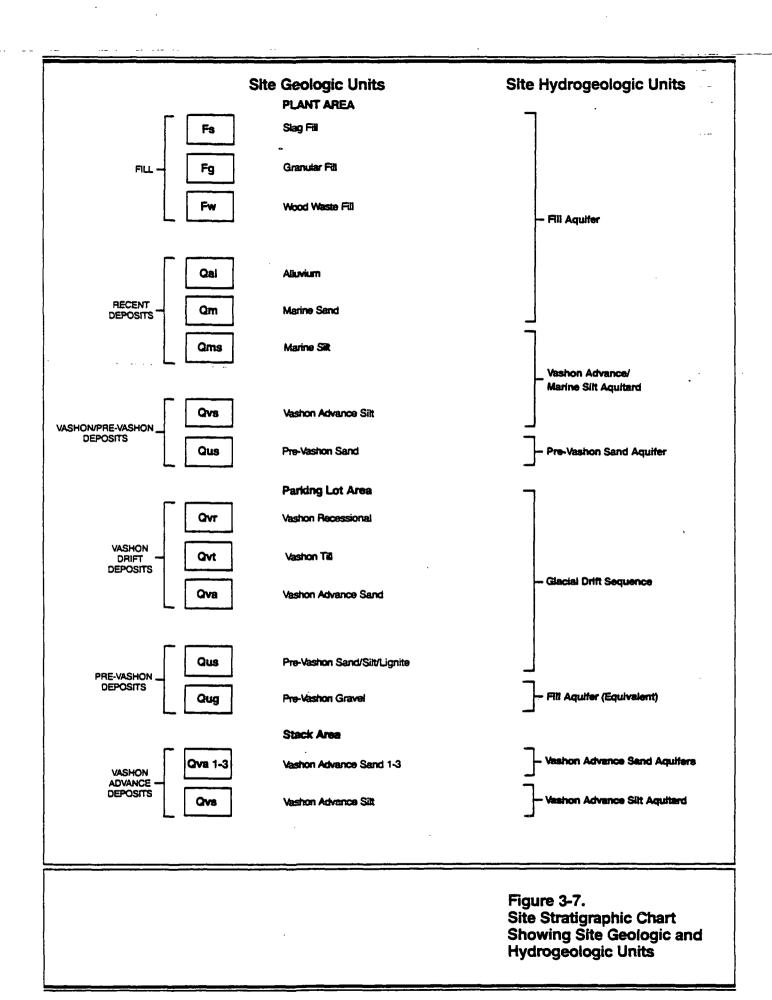


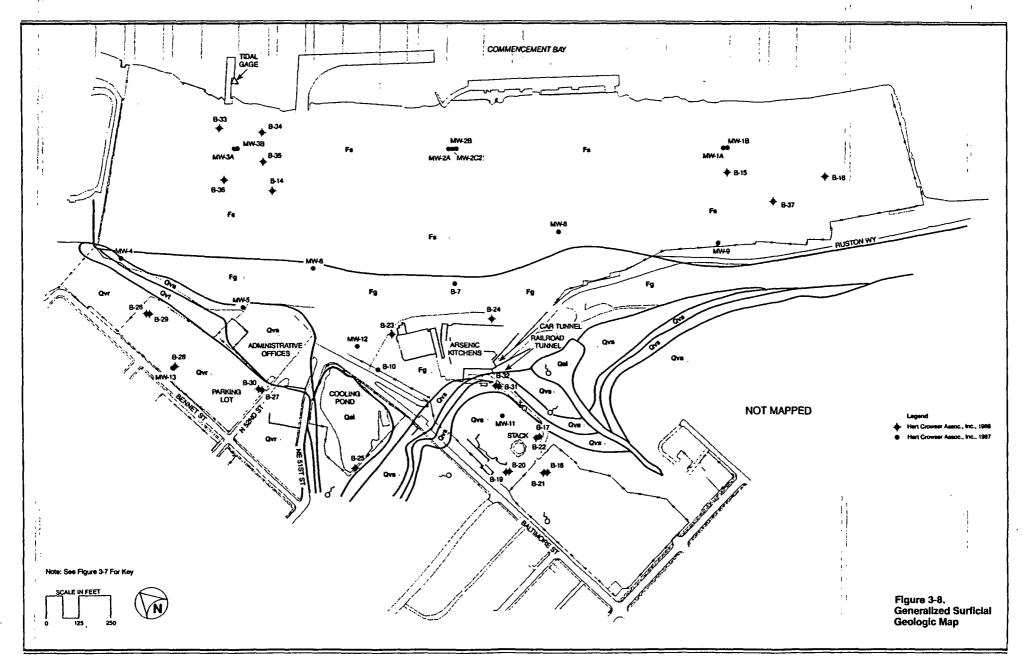
Figure 3-3.
Hydrographs for the middle outfall catchment area: Stations SW-1, SW-2, SW-3, SW-4, SW-5, SW-10

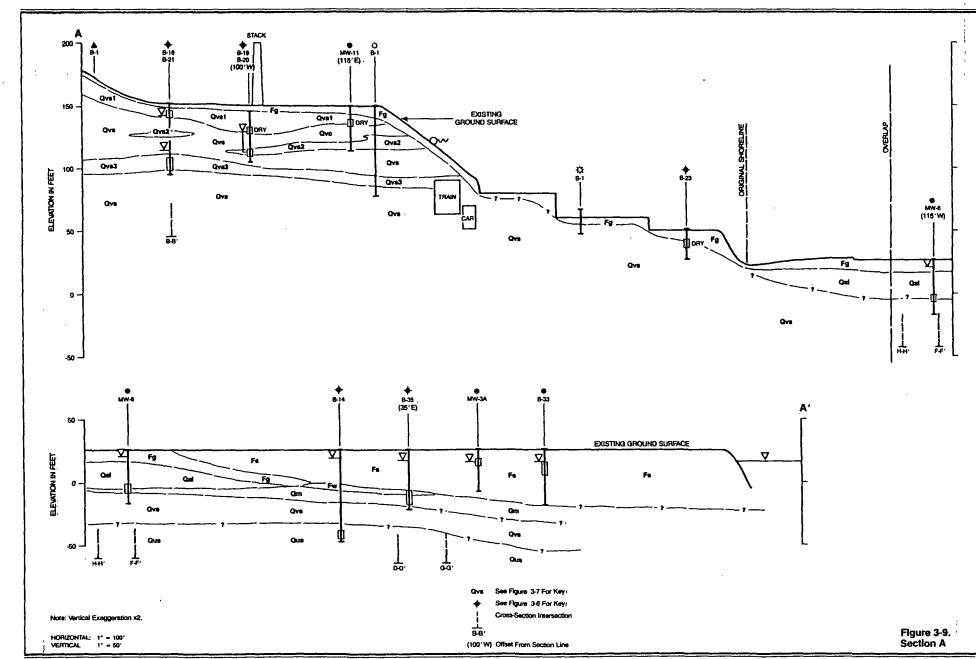


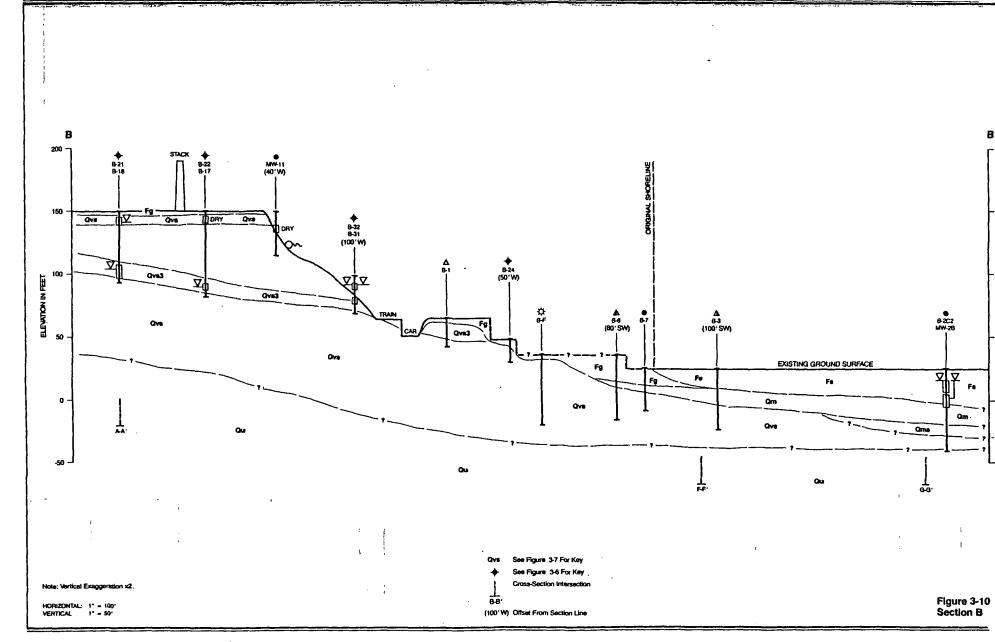






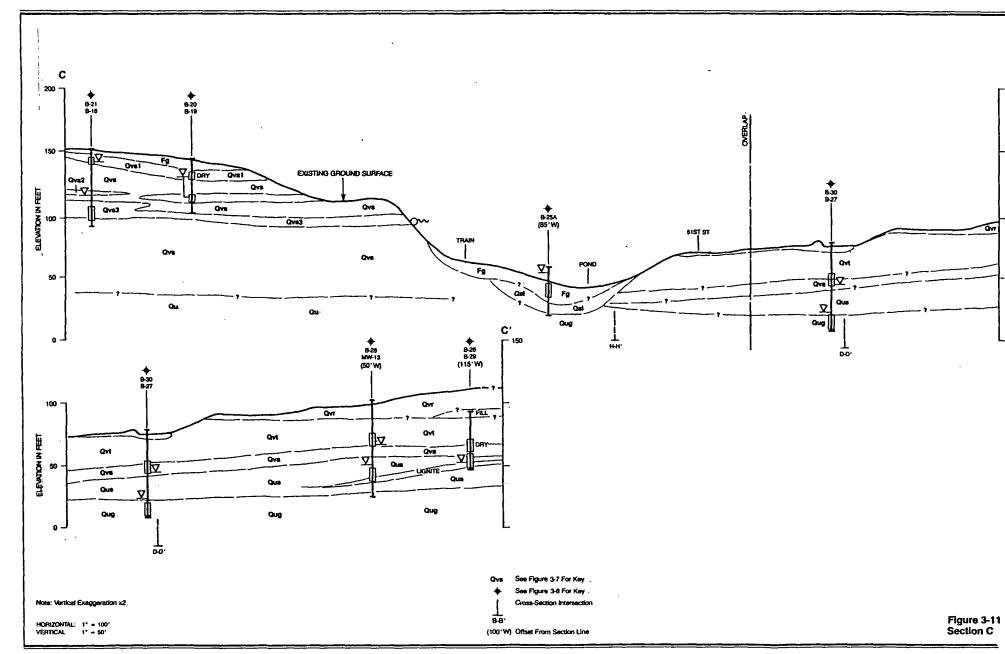






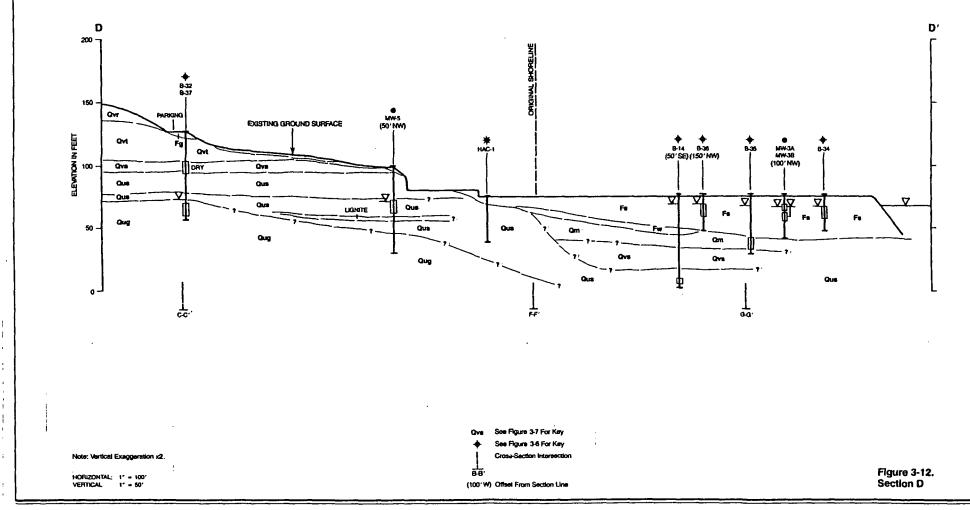
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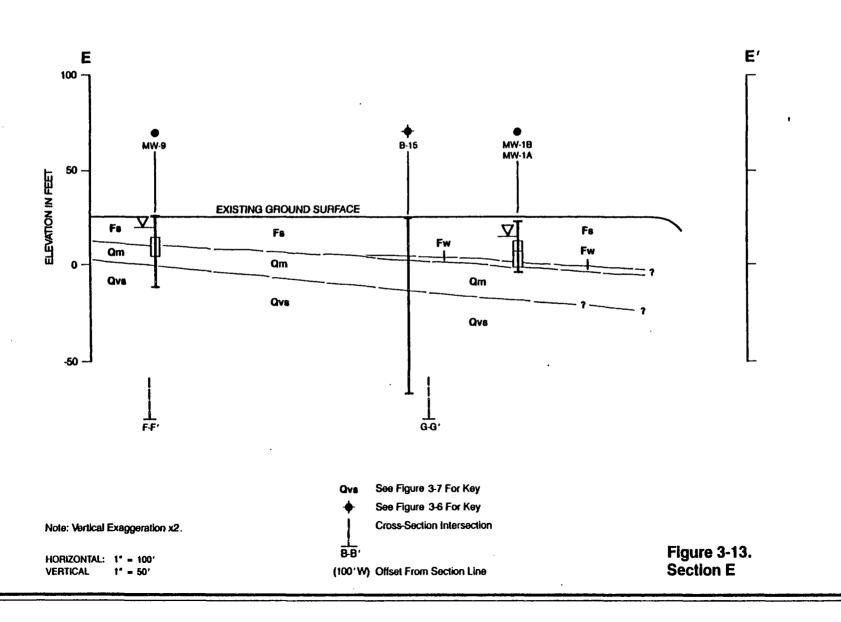
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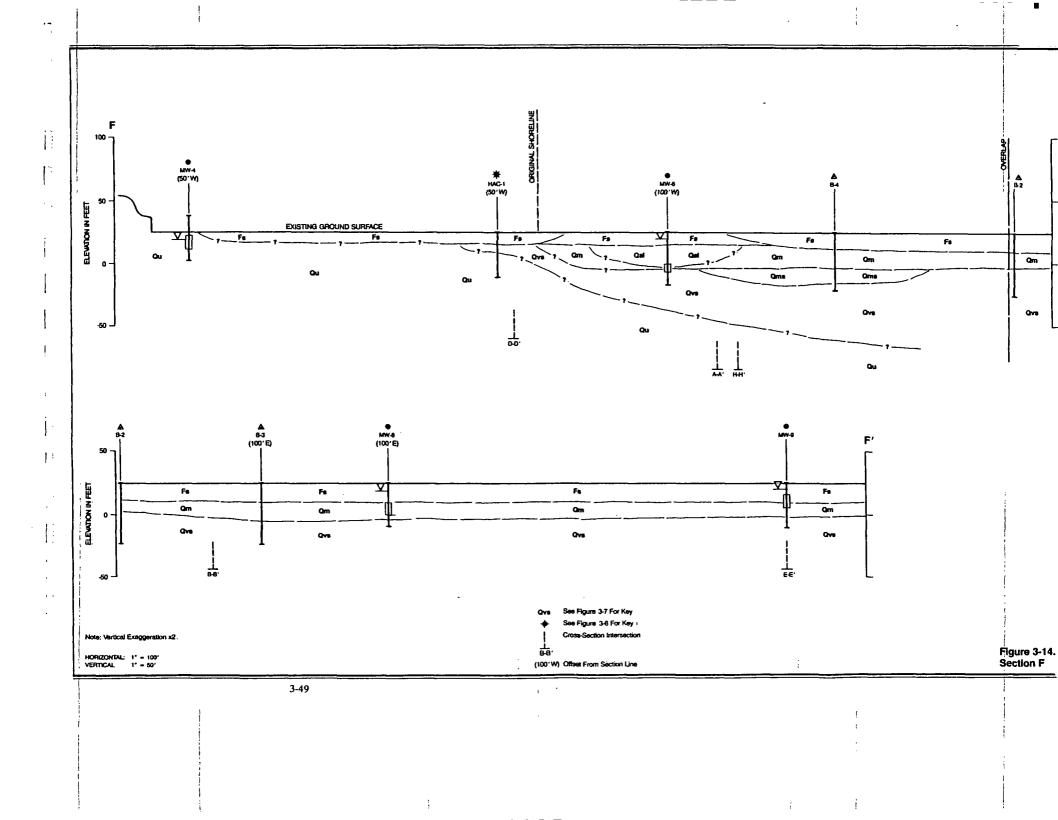


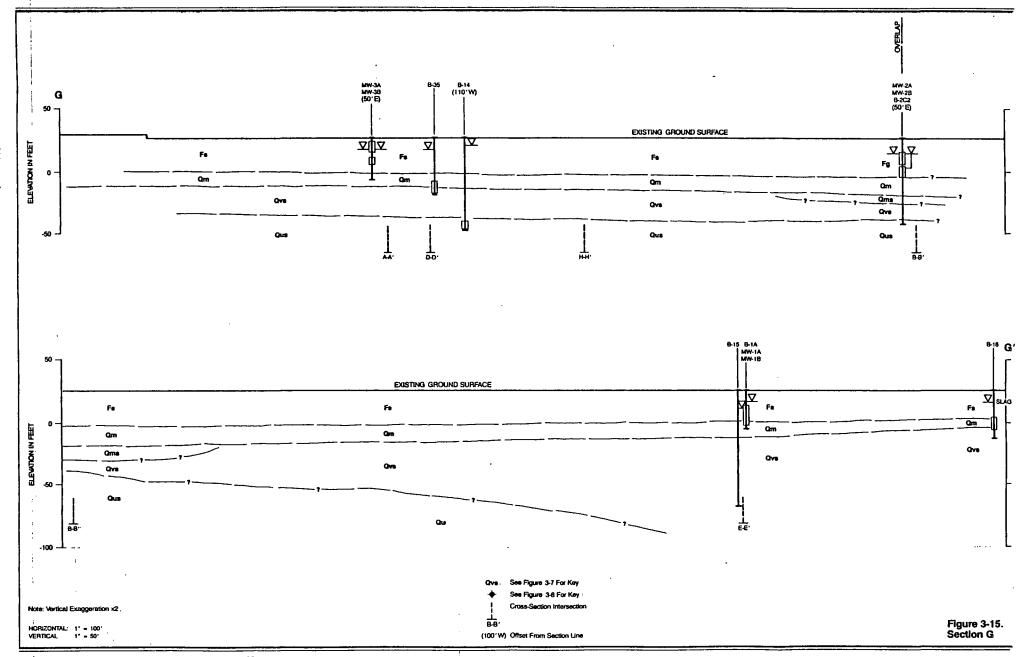
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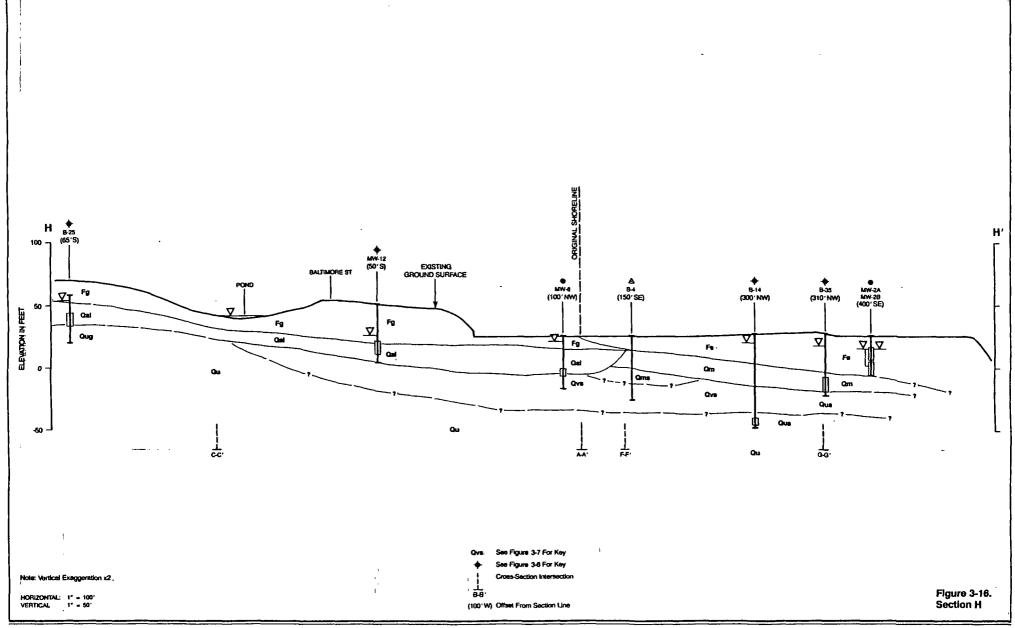
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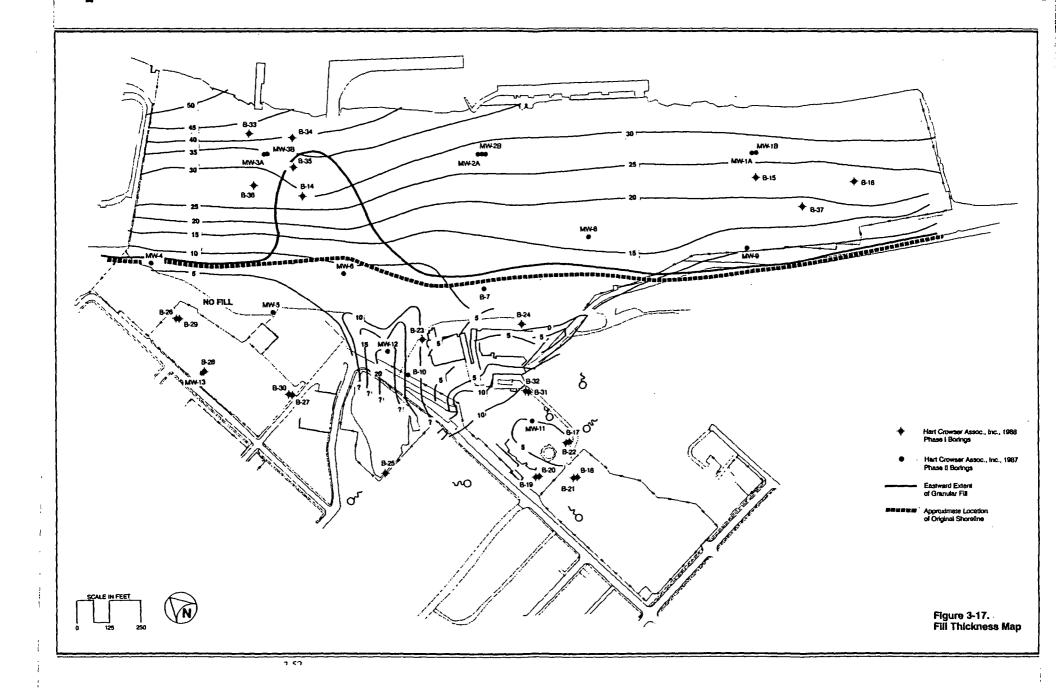


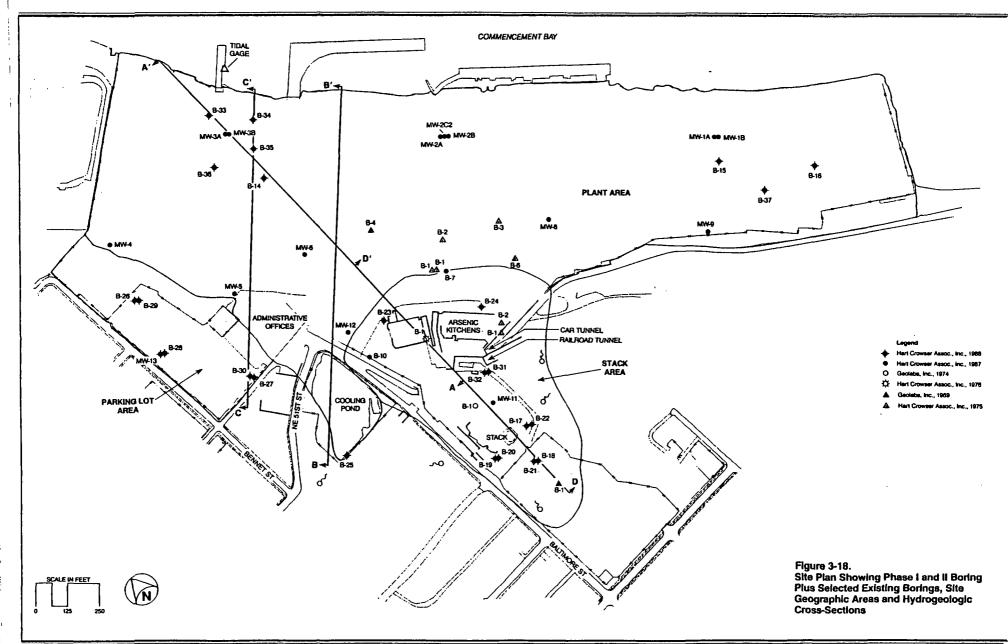


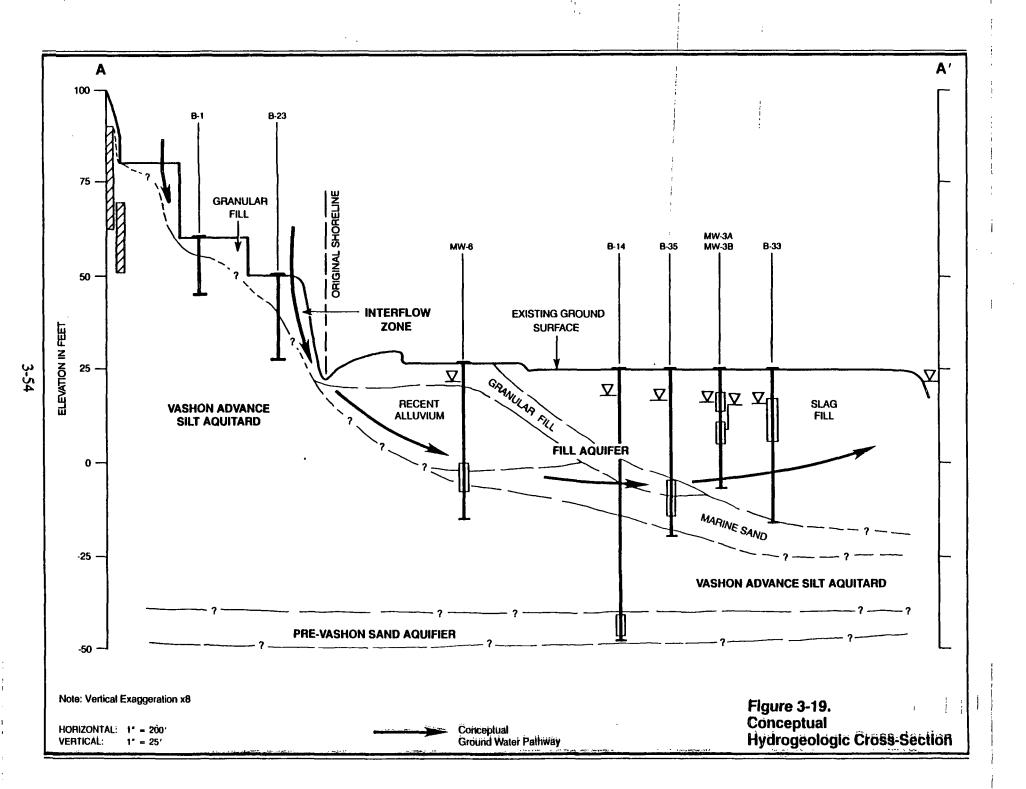


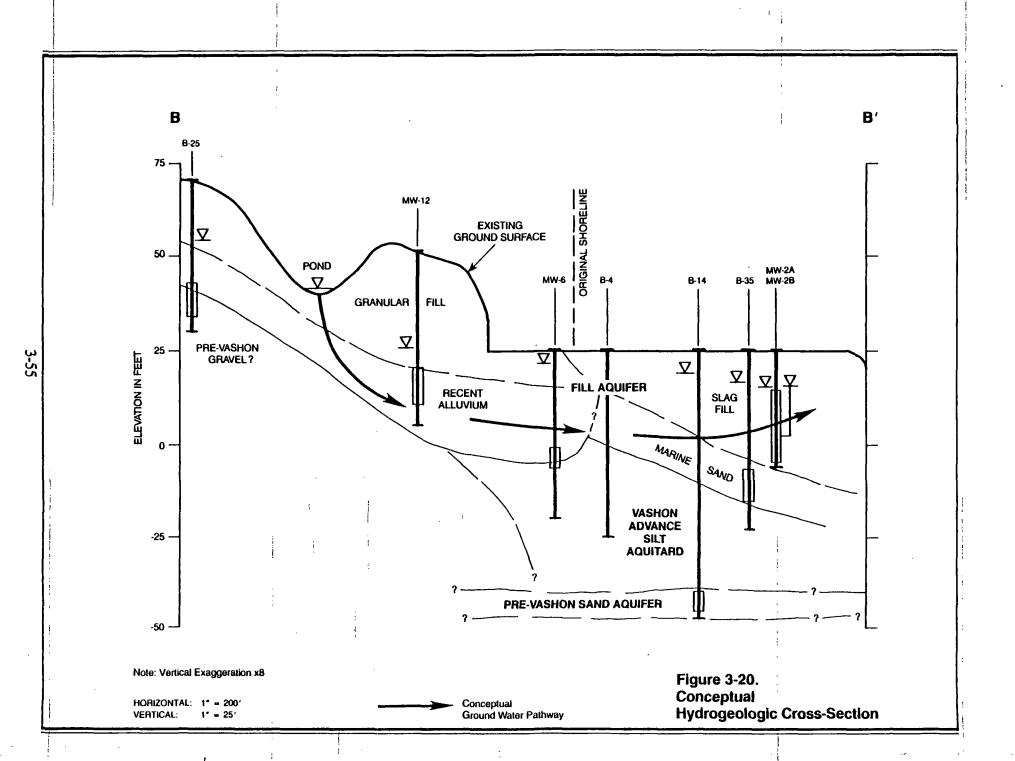


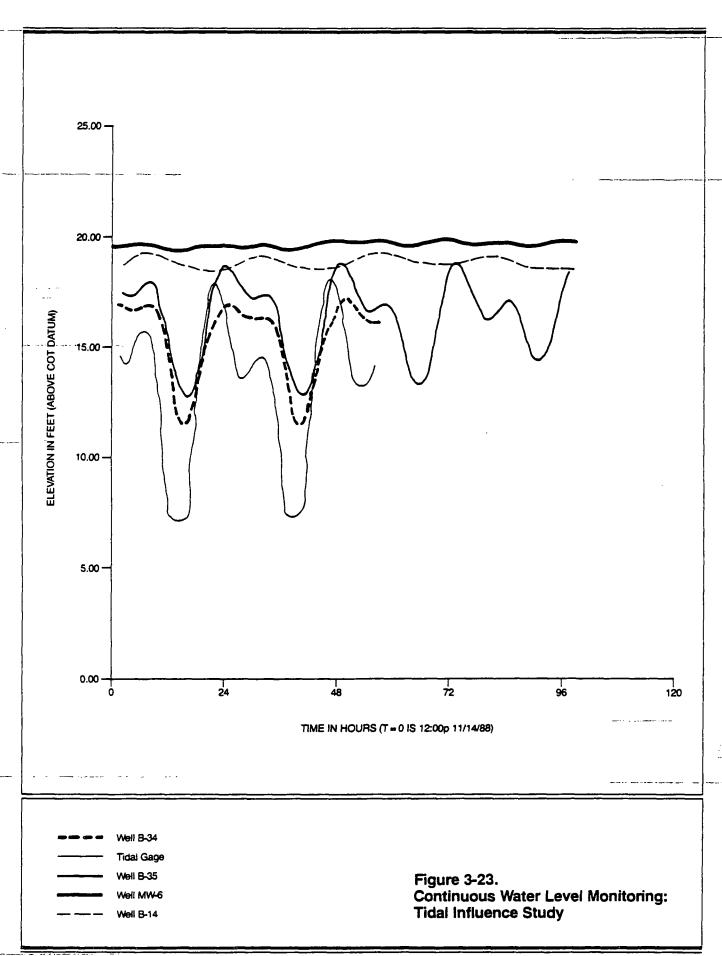


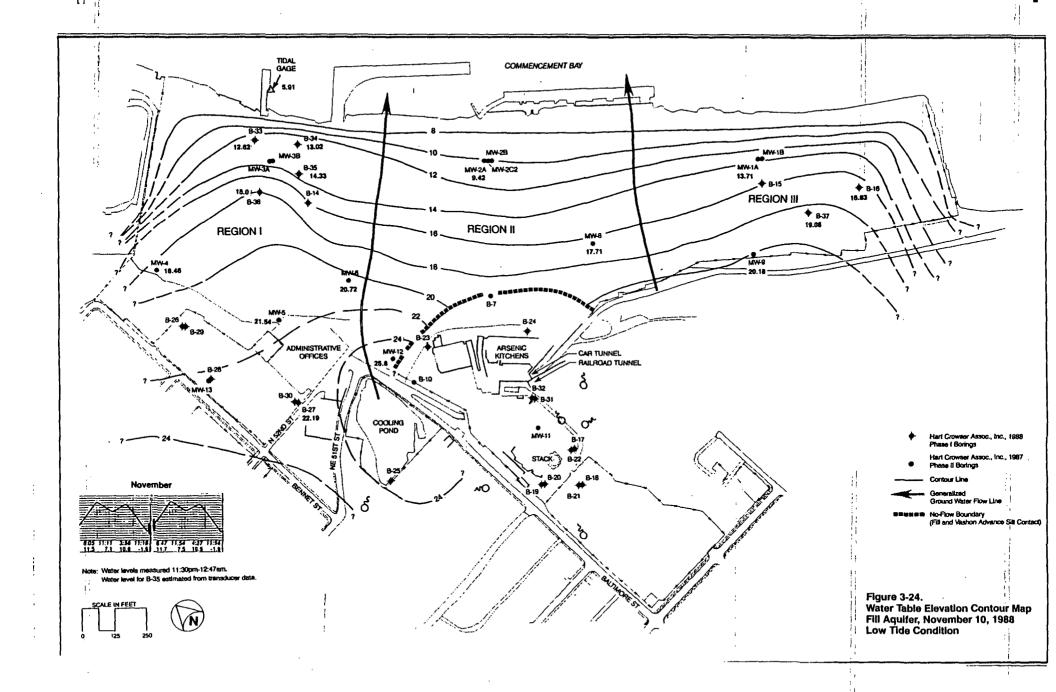


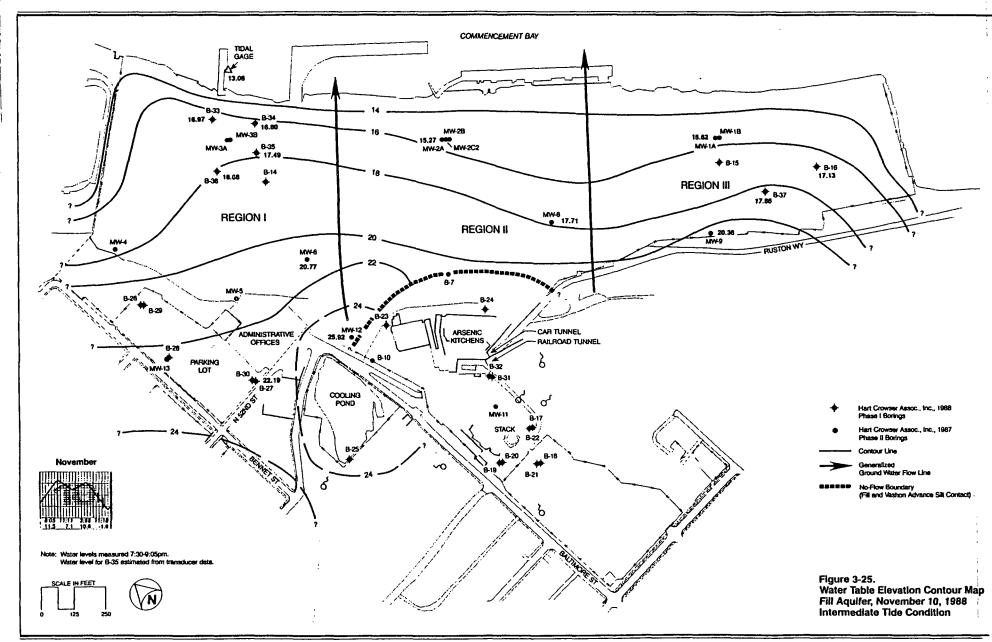


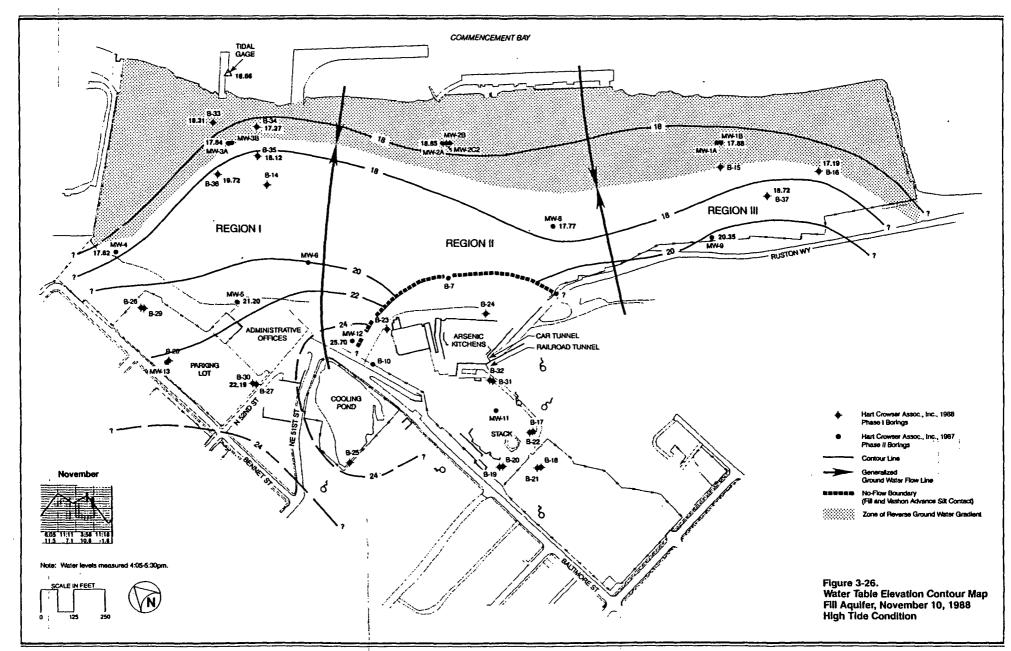


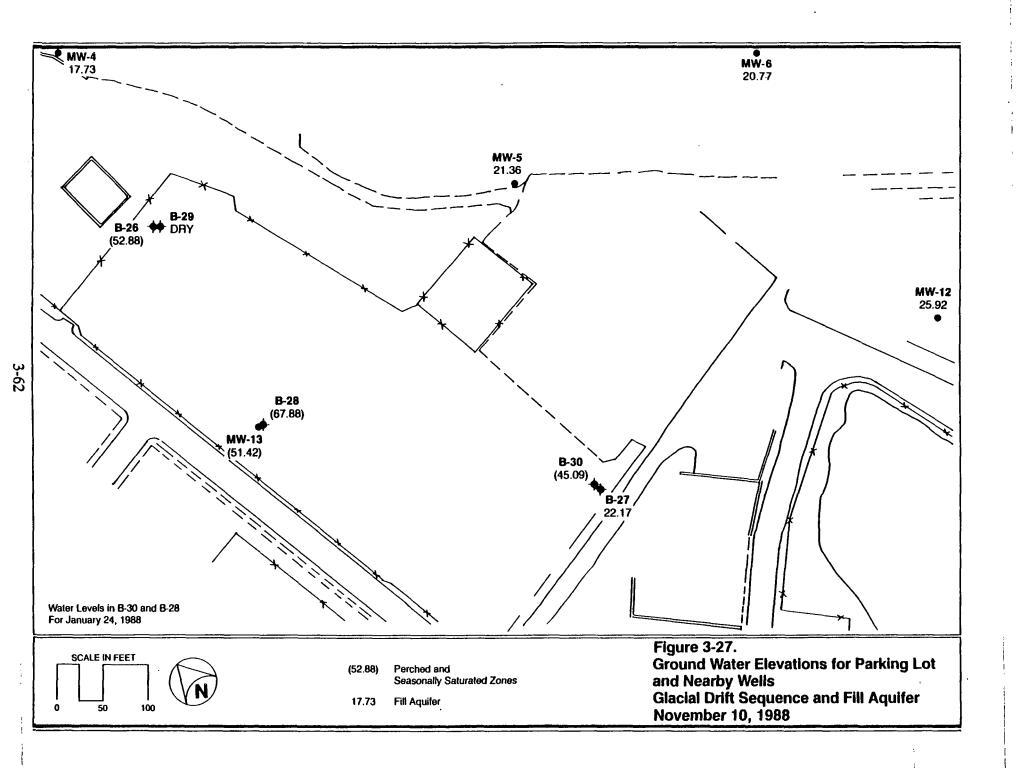


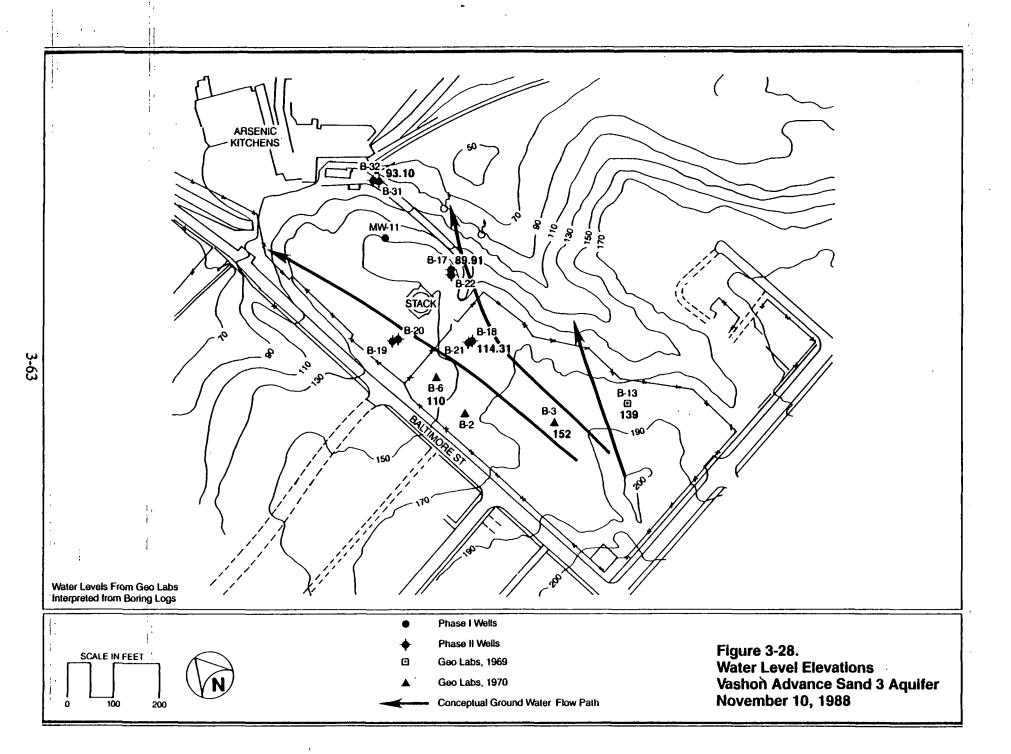


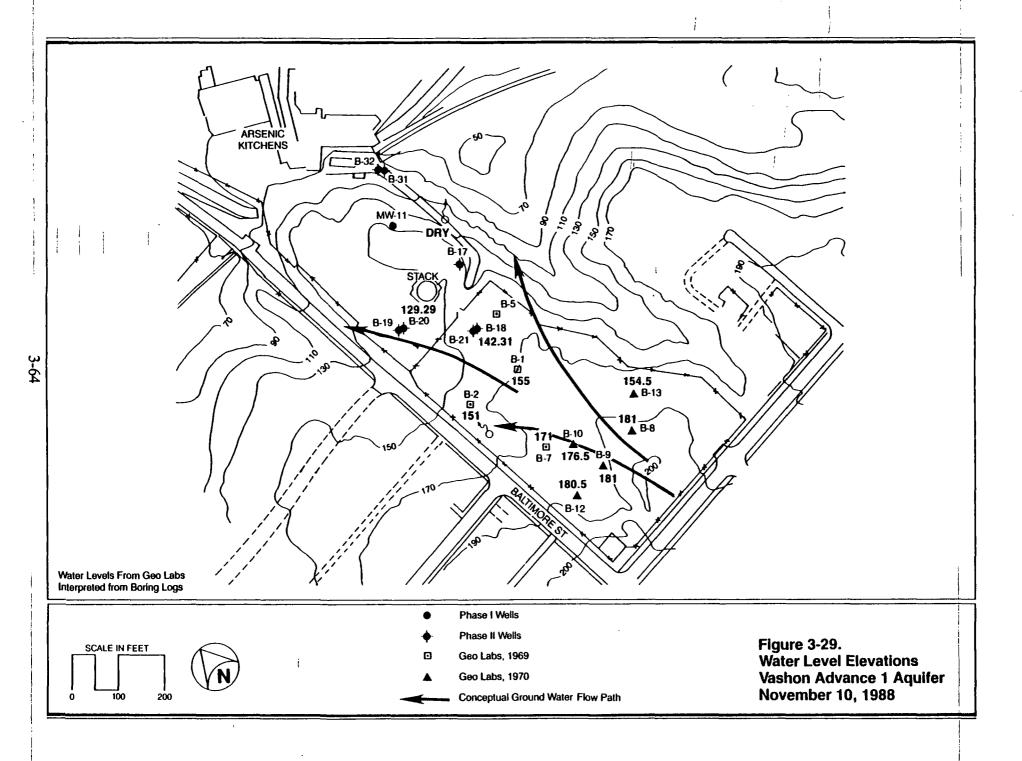


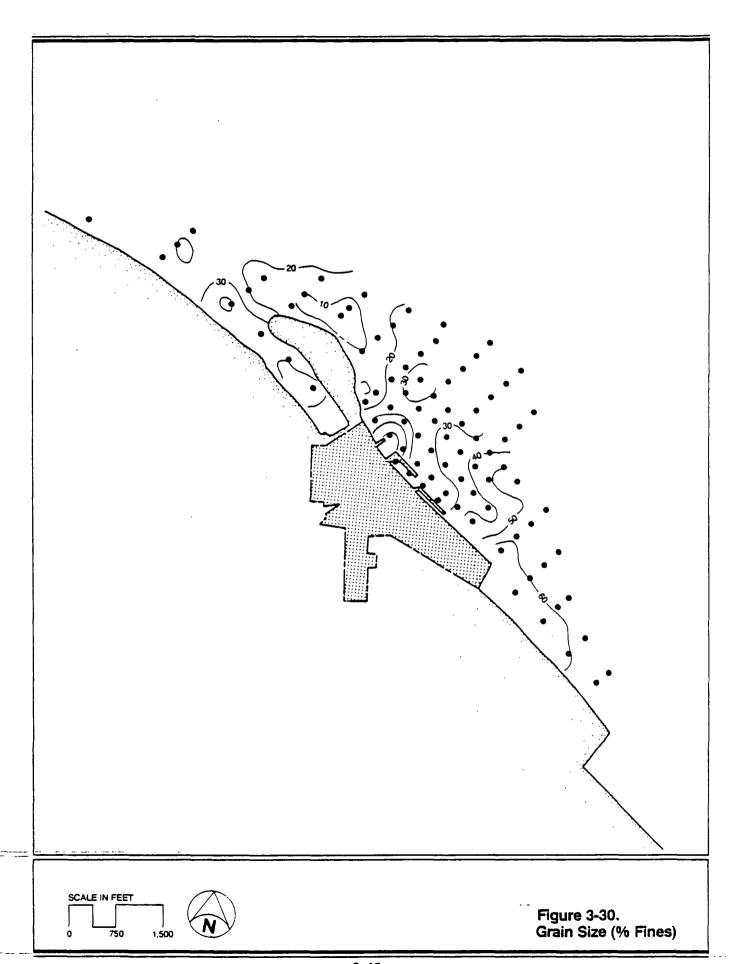


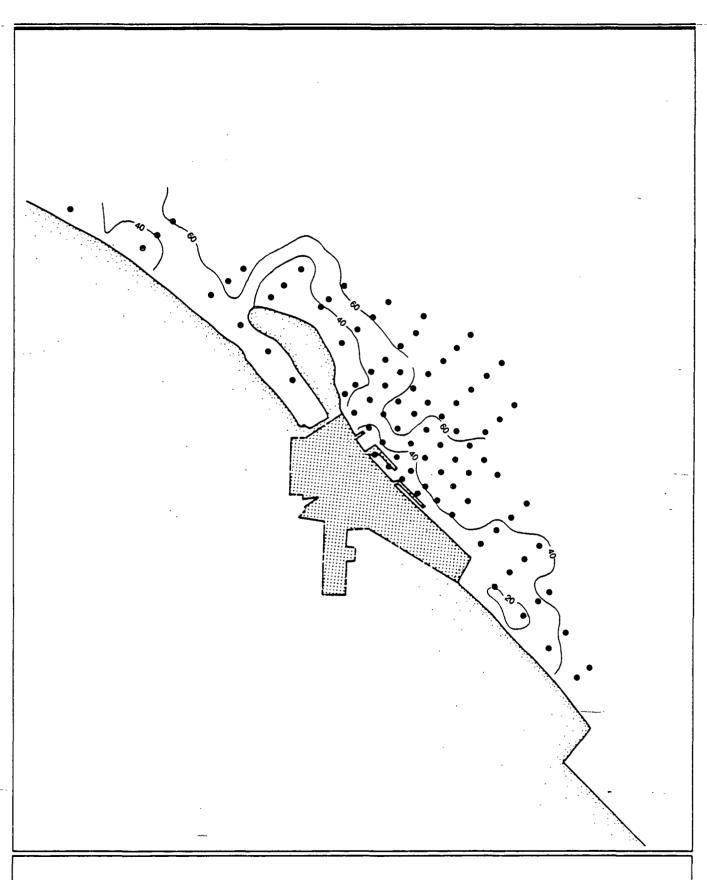












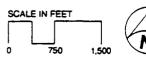
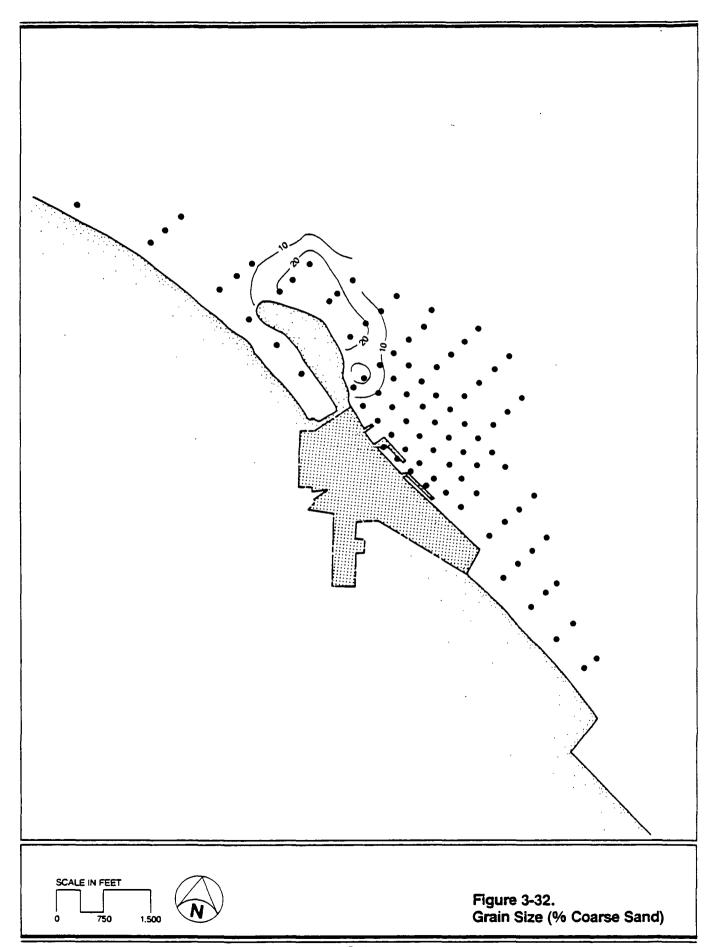
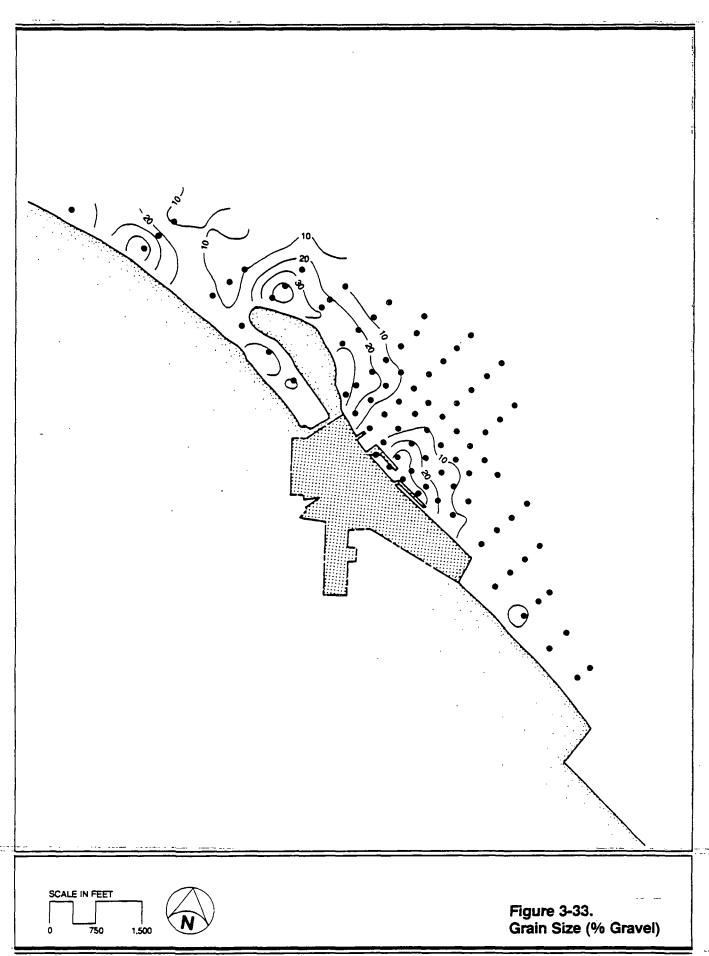


Figure 3-31. Grain Size (% Medium Sand)





#### 4.0 NATURE AND EXTENT OF CONTAMINATION

## 4.1 AIR QUALITY

As mentioned in Section 2.4, 22 soil samples were collected for dust analysis. These dusts were separated into three particle fractions and chemical concentrations measured for each fraction. The goal in analyzing the individual particle fractions for inorganic species was to determine if there was a significant difference between the inorganic concentrations of the three particle sizes. This is important from an air pollution modeling standpoint because if the inorganic concentrations between the different particle sizes are different, then the modeling for off-site particle migration becomes more complex. Conversely, if there is no significant difference between the concentrations of the different particle sizes, the particle emissions are assumed valid for the total particle distribution on-site.

The differences in the inorganic concentrations were estimated between the fine and coarse particle fractions, the fine and total particle fractions, and the coarse and total particle fractions.

- fine particles, 0-2.5  $\mu$  in diameter
- coarse particles, 2.5-10.0  $\mu$  in diameter
- total particles, 0-30.0  $\mu$  in diameter.

The differences were statistically "estimated" because the true population means are unknown. To estimate the concentration differences between two populations, a confidence interval with the following format is normally used.

• Point estimate + (interval coefficient)\*(standard error of the estimate)

In the case of the Asarco dust sample analyzed by NEA, Inc., the point estimate is the difference between the average concentrations of an inorganic specie between two different particle classes. For example, the average concentrations of chromium in the fine and coarse particle fractions of the 22 samples is 0.0628 percent and 0.063 percent, respectively. Therefore, the point estimate of the difference between the chromium concentrations of the two populations is 0.0002 percent.

The interval coefficient is the number of standard errors on either side of the population mean necessary to include a percentage of the possible sample means equal to the confidence level. It is a t-value from the "Student t distribution" with the appropriate degrees of freedom equal to  $n_1 + n_2 - 2 = 42$ . The standard error of the estimate is the square root of a weighted average of the sample variances multiplied by the square root of a weighted average of the population sizes. The populations were assumed to be randomly distributed, to be independent, and to have equal standard deviations.

At the 95-percent confidence limit, the true differences between the inorganic concentrations of the three particle classes were estimated. The confidence intervals are listed in Table 4-1. Since a high degree of confidence was used for the analysis (that is, we are almost certain the interval contains the true mean difference) and the intervals all contain zero, there is no basis for concluding that concentrations of inorganic species vary significantly between the different classes of particles at the 95-percent confidence limit.

The analytical procedures used by NEA to analyze the surface dust samples appear to be acceptable. The analyses of the reference standards was within acceptable limits. Maximum deviations of the reference sample cannot exceed 5 percent of the true value. During the period when the Asarco samples were being analyzed, the maximum percent deviation of the reference standard was only 3 percent.

The statistical comparison of the concentrations of inorganic species in the three particle classes indicated there was no statistical difference in the concentrations of any species at the 95-percent confidence limit. Reductions in the confidence interval did reveal differences in some species; however, it is uncommon for conclusions to be drawn from confidence intervals less than 95 percent.

## 4.2 SURFACE WATER

#### 4.2.1 CONVENTIONAL MEASUREMENTS

The conventional parameters (measurements) investigated include temperature, pH, conductivity, and total suspended solids. Hourly measurements of temperature, pH, and conductivity are tabulated in Surface Water Field Data (Volume 2, Appendix H - Surface Water). Total suspended solids results are tabulated in Surface Water Metals Data (Volume 2, Appendix H).

Water temperatures varied with air temperature. Generally, water temperatures were about 10°C during Events 1 and 2 and about 13°C during Event 3. Water temperatures at SW-7 were elevated above 20°C during periods of low flow. Steam was observed coming out of the manhole at SW-7. This was because boiler steam condensate was discharged into the drainage line above SW-7. The boiler has been shut down.

Generally, pH ranged from 6 to 10 in the surface water. Samples of lowest pH were collected at SW-12 and SW-11, which drain the acid plant and SO<sub>2</sub> plant areas. Samples of highest pH were collected during periods of low flow at SW-7, indicating that the cooling water discharge is alkaline.

Conductivity varies with the concentration and type of dissolved ions in water. There was a trend at most stations for conductivity to increase as flow decreased. Thus, there was a higher concentration of dissolved ions during periods of low flow.

Table 4-1. Estimated differences in concentrations of inorganic species between different particle sizes at the 95 percent confidence limit.

Fine Particles	Versus Co	parse Particles		- 1 - 1 - 2 - 2	
Compound		Pt. Estimate	(Int. Coeff)x (Std. Error)	Estimated Differ in Concentration	
Chromium	(CR)	-0.0003 +-	0.0215	-0.0217> 0.0	)212
Nickel	(NI)	0.0160 +-	0.0386	-0.0226> 0.0	)546
Copper	(CÚ)	0.1585 +-	1.8105	-1.6521> 1.9	9690
Zinc	(ZN)	0.1147 +-	0.1530	-0.0383> 0.2	2677
Arsenic	(AS)	-0.3260 +-	3.9641	<b>-4.2901&gt; 3.6</b>	5381
Selenium	(SE)	0.0225 +-	0.0709		)934
Silver	(AG)	0.0054 +-	0.0425		)479
Cadmium	(CD)	-0.0111 +-	0.0361		)250-
Antimony	(SB)	0.0949 +-	0.4164		5113
Мегсигу	(HG)	0.1092 +-	0.3433		1525
Lead	(PB)	1.1053 +-	1.1295	-0.0242> 2.2	2348
Fine Particles	Versus To	stal Particles			
Chromium	(CR)	0.0030 +-	0.0193	-0.0163> 0.0	)223
Nickel	(NI)	0.0030 +-	0.0381		)593
Copper	(CU)	0.1967 +-	1.8092		0059
Zinc	(ZN)	0.1030 +-	0.1646		2676
Arsenic	(AS)	-1.3975 +-	5.2685		3710
Selenium	(SE)	0.0275 +-	0.0712		988
Silver	(AG)	0.0116 +-	0.0406		)522
Cadmium	(CD)	0.0143 +-	0.0231		375
Antimony	(SB)	0.2343 +-	0.4076		5419
Mercury	(HG)	0.1495 +-	0.3349		1844
Lead	(PB)	1.0363 +-	1.1752		2115
Coneca Partiala	c Vozave	Coorse Porticles			
Chromium	(CR)	Coarse Particles 0.0032 +-	0.0213	-0.0181> 0.0	245
Nickel	(NI)	0.0052 +-	0.0213		)360
	(CU)	0.0032 +-	1.9109		9491
Copper Zinc	(ZN)	-0.0116 +-	0.1371		255
Arsenic	(AS)	-1.0715 +-	5.7039		325
Selenium	(SE)	0.0050 +-	0.0604		)655
Silver	(AG)	0.0062 +-	0.0411		1472
Cadmium	(AG) (CD)	0.0002 +-	0.0331		585
Antimony	(SB)	0.0233 +-	0.3465		859
Mercury	(SB) (HG)	0.0403 +-	0.2479		.882
Lead	(PB)	-0.0690 +-	0.7190		499

Conductivity ranged from a low of 14 umhos/cm at SW-6 to a high of 80,000 umhos/cm at SW-11 (marine water intrusion). Conductivity at SW-5, SW-6, and SW-8 was always less than 100 umhos/cm. These stations collect water from paved surfaces. Generally, conductivity at SW-1, SW-2, SW-4, SW-7, and SW-9 ranged from 100 to 200 umhos/cm. SW-1 and SW-2 are background residential runoff stations. Typically, conductivity at SW-3, SW-10, SW-12, and SW-13 ranged from 200 to 300 umhos/cm. These stations collect runoff and seepage from the stack area. Conductivity at SW-11 (south outfall) was usually greater than 300 umhos/cm, even when it wasn't affected by high tide. Conductivity at the seep stations, SP-1 through SP-5, was usually greater than 600 umhos/cm. Conductivity was less than 200 umhos/cm at secondary outfalls A, B, and D, but greater than 300 umhos/cm at secondary outfall C.

Mean concentrations of total suspended solids (TSS) for all three events are graphically presented in Figure 4-1. Stations in the middle outfall catchment basin all had relatively high TSS concentrations (>60 ppm). TSS gradually increased from 63 ppm at SW-2, to 81 ppm at SW-4, and to 91 ppm at SW-10.

The background and outfall TSS concentrations were less in the south outfall than the middle outfall catchment basin. TSS decreased slightly from 26 ppm at SW-1 to 20 ppm at SW-13, and then increased to 58 ppm at SW-12 and to 63 ppm at SW-11. This indicates some settling of solids between SW-1 and SW-13, and a large solids source between SW-13 and SW-12.

The mean TSS concentration at the north outfall (SW-9) was only 24 ppm, which is much less than the other outfalls. TSS concentrations at SW-7 and SW-8 were the highest of all primary stations (greater than 125 ppm). And the mean TSS concentration at SW-6 was the lowest of the primary stations (19 ppm).

Mean TSS concentrations at the secondary outfalls were relatively low and ranged from 5 to 33 ppm. Mean TSS concentrations at the seeps ranged from 3 to 71 ppm. High TSS concentrations at the seeps were due to disturbance of sediment during Event 1 sample collection.

## 4.2.2 METALS

All of the metals results are tabulated in Surface Water Metals Data (Volume 2, Appendix H). The flow-proportional mean metal concentrations at the primary stations were averaged arithmetically for the three sampling events. The grab sample metal concentrations from the secondary outfalls and seeps were also averaged arithmetically for the three sampling events. The detection limit was used for averaging when a metal was not detected in the sample. These mean concentrations are presented graphically for each metal (total and dissolved) in Figures 4-1 through 4-9. Metal concentrations at SW-8 and SP-3 are for only one grab sample. Total metal concentrations at SP-6 are for two samples from one sampling event. Dissolved metal concentrations were not determined at SP-6.

The concentrations presented in Figures 4-1 through 4-9 are grouped by catchment basins. For the middle and south outfalls, they are presented in the order they are located in the basin.—Stations SW-6, SW-7, and SW-8 are part of the city outfall basin, but are presented with the north outfall. The secondary outfalls and seeps are grouped separately. See Figure 2-4 for station locations.

The mean concentrations of total metals at the three primary outfalls are compared to marine chronic-criteria (USEPA 1986b) in Table 4-2. This table also presents the ratio of mean outfall concentrations to criteria concentrations. These ratios are equal to the average minimum amount of outfall dilution required to meet water quality criteria dueingt periods of rainfall. Copper has by far the highest ratios, which means it would require the most dilution for the outfalls to meet water quality criteria. Outfall dilution is discussed in Section 5.3.2.

Annual loading estimates of total metals from the three primary outfalls are presented in Table 4-3. The average annual loading for the three sampling events was calculated by multiplying the mean metal concentration by the mean total flow at each outfall. Annual loading was then estimated by dividing this value by the average rainfall during each sampling event (0.15 inches) and multiplying by the 20-yr average annual rainfall at the City of Tacoma's Central Wastewater Treatment Plant (located near the smelter site), 37.33 inches per year from 1969 to 1988.

Table 4-2. Marine chronic criteria and ratios of mean outfall concentrations of total metals to criteria. (The ratios of metal concentrations to marine chronic criteria are in parenthesis.)

	Antimony	Arsenic	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
Marine chronic	1,600	36	9.3	2.9	5.6	0.025	13	58
Middle outfall	40	2,767	97	5,557	292	2.000	50	2,803
	(<1:1)	(77:1)	(10:1)	(1,916:1)	(52:1)	(80:1)	(4:1)	(48:1)
South outfall	98	4,797	219	15,127	516	4.050	23	12,737
	(<1:1)	(133:1)	(24:1)	(5,216:1)	(92:1)	(162:1)	(9:1)	(220:1)
North outfall	308	884	10	2,344	646	0.650	87	373
	(<1:1)	(25:1)	(1:1)	(808:1)	(115:1)	(26:1)	(7:1)	- (6:1)

<sup>&</sup>lt;sup>1</sup>All values are from USEPA 1986b. The antimony value is a fresh water chronic criterion because there is no marine criteria for antimony.

Table 4-3. Annual loading estimates of total metals from the three primary outfalls in grams per year.

	Antimony	Arsenic	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
Middle outfall	1.5	105	3.7	211	11.1	0.076	1.9	106
South outfall	0.6	29	1.3	91	3.1	0.024	0.7	76
North outfall	<u>0.4</u>	_1	0.0	_3	0.9	0.001	<u>0.1</u>	_1
Total	2.5	135	5.0	305	15.1	0.101	2.7	183

The annual loading estimates should be viewed with caution because of various environmental factors. These factors include the quantity, intensity, duration, and weather conditions preceding a rainfall event, as well as tidal conditions. The three rainfall events sampled for the surface water investigations were relatively low in quantity and intensity. Larger and more intense storms would likely generate surface water flows that would carry proportionately more sediment and metals associated with that sediment. This increase in surface water would effectively increase the metals concentration. Also, two of the three events were sampled during an ebb tide when initial flows contained backed-up water. In summary, the sampling of small rainfall events may have underestimated the mean metal concentrations, while the sampling of two ebb tides may have overestimated mean flows. These errors would have opposing effects on loading estimates.

## 4.2.2.1 Antimony

Antimony was rarely detected in the middle and south outfall basins. Elevated concentrations of total antimony (>0.1 ppm) were observed at SW-7, SW-8, SW-9 (north outfall), and secondary outfalls B and D (Figure 4-2). Most of the antimony in the north outfall was dissolved.

The mean concentration of total antimony was less than the fresh water chronic criteria at the primary outfall stations (Table 4-2), and all other surface water stations. The annual loading estimate for antimony from the three outfalls was 2.5 g/yr (Table 4-3).

## 4.2.2.2 Arsenic

Arsenic was detected in every surface water sample. The mean concentration of total and dissolved arsenic increased dramatically from SW-4 to the middle outfall (Figure 4-3). An even more dramatic increase was observed from SW-13 to the south outfall. Because the flows do not increase much between these stations, there must be a very large source of arsenic in Asarco's central plant area. This source of arsenic is in both a dissolved and particulate state. The arsenic source could be highly contaminated runoff, groundwater, or pipe sediment.

Runoff generated on the Asarco plant was monitored at Stations SW-7, SW-8, SW-9, and the secondary outfalls. While the arsenic concentration was elevated above background (SW-1 and SW-2) at these stations, it was still less than levels in the middle and south outfall. However, these stations are not located in the central plant area where there could be a large source of arsenic contributing to elevated arsenic levels in site runoff.

A very high concentration of total arsenic was observed in a tunnel seep sample (1530 ppm). This high concentration is evidence groundwater is a source of arsenic to the middle and south outfalls. The possible mechanisms for groundwater contamination of surface runoff is discussed in Section 5.1.2.

Another source for the elevated arsenic levels at the outfalls is the mobilization of sediment that has collected in the drainage pipes over the years of plant operation. The pipes have a slight slope, which allows for sediment accumulation during periods of low flow. The accumulated sediment is then flushed out of the pipes during periods of high flow. However, this flushing would elevate the particulate arsenic levels, but would not account for the elevated dissolved arsenic levels.

Higher arsenic concentrations were observed at seeps 3, 4, and 5 than at seeps 1 and 2. This can be explained by the location of the seeps. Seeps 3, 4, and 5 are located down the hill from the stack area, while seeps 1 and 2 are located on the slope of a hill southeast of the stack area. The high concentration of total arsenic at SP-5 was a result of the sample from Event 1 that disturbed the soil in the seep hole. However, the seeps do not appear to elevate the arsenic concentration in the drainage channel they flow into. In fact, the total arsenic concentration decreased along the drainage channel from SW-1 to SW-13. This decrease was likely due to sedimentation of particulate arsenic in the drainage channel.

The mean concentration of total arsenic at the primary outfalls was 25 to 133 times the marine chronic criterion (Table 4-2). The marine chronic criterion was exceeded in all surface water samples. The annual loading of arsenic from the primary outfalls was estimated at 135 g/yr (Table 4-3). Approximately 80 percent of that load was from the middle outfall.

## 4.2.2.3 Cadmium

Cadmium concentrations had similar trends to that discussed for arsenic. However, the increase in cadmium concentration from SW-4 to the middle outfall and from SW-13 to the south outfall was even more dramatic than that observed for arsenic (Figure 4-4). Nearly all of the cadmium in the middle and south outfall was dissolved in the water.

The mean concentration of cadmium at the primary outfalls was 1 to 24 times the marine chronic criterion (Table 4-2). The background cadmium concentration at SW-1 and SW-2 was consistently less than the marine chronic criterion. The annual loading of cadmium from the three primary outfalls was estimated at 5 g/yr (Table 4-3).

# 4.2.2.4 Copper

Copper concentrations presented in Figure 4-5 are in nearly the same pattern as arsenic concentrations. Thus, the trends discussed for arsenic apply to copper.

The copper concentration in nearly all surface water samples exceeded marine chronic criteria. The total copper concentration at the primary outfall stations was 808 to 5,216 times the marine chronic criterion (Table 4-2). This increase above marine chronic criterion far exceeds that of any other metal. The annual load of copper was estimated to be 305 g/yr, with two-thirds of the total from the middle outfall and one-third of the total from the south outfall (Table 4-3).

#### 4.2.2.5 Lead

Total lead concentrations also increased from SW-4 to the middle outfall and from SW-13 to the south outfall (Figure 4-6). However, the magnitude of the increase was much less than for most other metals. Also, nearly all of the lead in the surface water samples was particulate lead associated with sediment. Lead concentrations in the north outfall and secondary outfalls were generally higher than in the middle and south outfalls. This suggests a predominant source of lead in Asarco plant runoff.

The total lead concentration of nearly all surface water samples exceeded marine chronic criteria. Mean lead concentrations at the primary outfalls were 52 to 115 times the marine chronic criteria (Table 4-2). The outfall loading estimate for lead was 15 g/yr.

# 4.2.2.6 Mercury

Total mercury concentrations had a similar pattern to arsenic concentrations (Figure 4-7). Like lead, however, most of the mercury was associated with suspended sediment.

Total mercury was not detected in many of the surface water samples, while dissolved mercury was rarely detected. Because the detection limit was 20 times the marine chronic criterion, the ratios estimates in Table 4-2 may be high. The annual loading of mercury at the primary outfalls was estimated at 0.1 g/yr.

#### 4.2.2.7 Nickel

Nickel was rarely detected at stations located upgradient of Asarco's central plant area (Figure 4-8). Elevated concentrations of nickel were observed at the primary and secondary outfalls. Most of the total nickel was dissolved and not associated with suspended sediment.

The ratio of nickel concentrations to marine chronic criteria at the primary outfalls is less than 10 (Table 4-2). The annual loading estimate for nickel at the primary outfalls is 2.7 g/yr (Table 4-3).

#### 4.2.2.8 Zinc

Zinc concentrations presented in Figure 4-9 follow the same pattern described for arsenic. The increase in zinc concentration from SW-4 to the middle outfall and from SW-13 to the south outfall was even more significant than that observed for arsenic. Like cadmium, most of the zinc at the middle and south outfalls was dissolved in the water.

The mean concentration of zinc at the primary outfalls was 6 to 220 times the marine chronic criterion (Table 4-2). Nearly all of the surface water samples had a total zinc concentration that exceeds the marine chronic criterion. Samples from SW-13 and seeps 1 through 4 were exceptions. The annual zinc load at the primary outfalls is estimated at 183 g/yr (Table 4-3).

### 4.2.3 ORGANICS

Surface water organics results are tabulated in Volume 2, Appendix H. The only organics detected in the surface water samples were phthalate esters. Bis(2-ethylhexyl) phthalate was detected at secondary outfall A (110 ppb), secondary outfall C (20 ppb), and SW-5 (20 ppb). Di-n-butyl phthalate was detected at secondary outfall C (30 ppb).

#### 4.3 SURFACE SOIL

A total of 99 surface soils samples were collected during two rounds of field investigation. Laboratory results for all analytical parameters for each sampling station are shown in Volume 2 - Technical Data. Additional surface soil samples were collected by Hart Crowser during the installation of monitoring wells. These samples are referred to in this section as "MW." MW-1-S-1 corresponds to the surface soil sample collected from the location of MW-1. Detailed tables listing all data for each sampling station are included in Volume 2 - Technical Data as Tables I-1 through I-4. For Tables I-3 and I-4, the results of QA/QC samples such as matrix spikes and duplicates are shown in addition to soil sample results. These are discussed in Volume 3 - Data Validation Reports (Appendix P). For purposes of this discussion, only data that passed QA/QC review are discussed.

Concentration gradient isopleths of total metals were generated for three sampling areas. Figure 4-10 shows the locations of all surface soil sampling stations, and the areas for which gradient isopleths were generated. The isopleth figures were generated by th4e software program SURFER (Golden Software 1987), and were plotted for the Site Stabilization and Cooling Pond Areas combined, the Administrative Area and the Off-Site Area. Selected isopleth figures are included as Figures 4-11 through 4-20. All of the surfer figures generated are included in Appendix G - Concentration Gradient Isopleths for Surficial Soils Samples.

#### 4.3.1 TOTAL METALS ANALYSIS

In general, the highest concentrations of metals were found in the Site Stabilization and Cooling Pond Area near the former arsenic plant, arsenic kitchens, cottrells, and godfrey roasters (see Figure 1-2 for locations). No samples were designated as "background samples" because there is virtually no native soil left in the plant vicinity. Of the fill material and slag that could be sampled in the vicinity, all that was sampled appeared to be influenced by contamination from the site. Other studies indicate that background levels of arsenic and cadmium in Regional Puget Sound soils is estimated at 140 ppm and 0.6 ppm, respectively (Lowry et al.). Using these background figures, all but two samples (MW-13-S-1 and SS-67) exceeded background levels for arsenic. All but two samples (MW-13-S1 and SS-67) exceeded these background levels for cadmium. Concentration gradients for individual metals in the Site Stabilization and Cooling Pond Area generated a wide variety of patterns.

The concentration gradients were similar for most metals analyzed in the Administrative Area exhibited a pattern. In the Administrative Area, concentrations were highest near

the boundary of the Site Stabilization Area, decreased to the north, and increased again near the northwest corner of the Administrative Sampling Area. The concentration gradients for metals in the off-site area generated a number of gradients, indicating several areas that have isolated high levels or concentrations that are elevated relative to surrounding areas. Because the isopleths were so varied, none of the off-site figures were included in this section.

The highest level of arsenic analyzed was 262,250 ppm, adjacent to the former arsenic plant (SS-2). An isopleth representation of the concentrations of arsenic found in the surficial soil samples in the Site Stabilization and Cooling Pond Area is included as Figure 4-11. Arsenic concentrations varied in the Site Stabilization and Cooling Pond Area. In general, concentrations were lower near the stack and increased down the hillside to the northwest towards Station SS-2, where the highest level was measured. Other high levels of arsenic (20,000 - 33,225 ppm) were found near the godfrey roasters, arsenic kitchens, and metallic arsenic plant.

See Figure 4-12 for the arsenic concentrations isopleth in the Administrative Area. The lowest level, 11 ppm, was found in the borehole at monitoring well MW-13, MW-13-S-1. Arsenic concentrations measured in samples collected in the Off-Site Area during Round 2 had higher levels of arsenic than on-site samples collected from the Administrative Area during Round 1.

Concentrations of cadmium across the Site Stabilization and Cooling Pond Area exhibited a similar distribution to arsenic (see Figure 4-13). The highest concentration was 498 ppm found at SS-16, just northwest of the arsenic kitchens. The cadmium concentrations found across all sampling stations ranged from 0.48 ppm to 498 ppm. See Figure 4-14 for the cadmium concentration isopleth in the Administrative Area.

High chromium concentrations were found at a number of sites, including the arsenic plant area, the refinery areas, and the cooling pond. Since the concentrations of chromium were very scattered in these areas, the isopleth generated (Appendix G) was not a useful visual presentation of this data. The range of concentrations was 21 to 142 ppm.

Lead concentrations were highest in the cottrell area and northeast of the arsenic plant in the Site Stabilization and Cooling Pond Area. Lead concentrations were very scattered throughout the Site Stabilization and Cooling Pond Areas. See Figure 4-15 for the distribution of lead in the Administrative Area. The range of concentrations was 12 to 22,600 ppm.

Antimony concentrations were highest at SS-2, the same site where the highest arsenic concentrations were found. The range of concentrations was from undetected to 3350 ppm. Many samples contained antimony concentrations below the detectable limit.

Mercury concentrations were very scattered throughout the Site Stabilization and Cooling Pond Area, but highest in the area of the cottrells, arsenic plant, and related processing activities. The range of concentrations was 3.0 to 695 ppm. Figure 4-16 shows the

distribution of mercury in the Administrative Area. It appears that there are two areas of relatively high concentrations: (1) in the southwest and (2) northeast corners of the sampling area.

Copper concentrations were highest in the cooling pond area and just north of the arsenic plant and boiler building (see Figures 4-17 and 4-18 for the distribution of copper across the Site Stabilization and Cooling Pond Area and the Administrative Area, respectively). The highest concentration of copper found on site was 341,250 ppm, in the Cooling Pond Area; in the arsenic plant area the highest level was 25,625 ppm. Sample SS2-04, collected from the bottom of the cooling pond, had a copper concentration of 62,250 ppm. The lowest level was 41 ppm (MW-13-S-1). In the cooling pond area, total copper concentrations were much greater in samples collected from the periphery of the cooling pond in Round 1 than in samples collected from the bottom of the cooling pond in Round 2.

Zinc concentrations were variable throughout the Site Stabilization and Cooling Pond Area, with the highest measured in SS-9A (14,800 ppm) and SS-9B (16,500 ppm), located between the godfrey roasters and the arsenic kitchen. The lowest level was 2.01 ppm (SS2-02). Figure 4-19 shows the distribution of zinc in the Administrative Area.

The distribution of nickel concentrations is similar to that of zinc in both the Site Stabilization and Cooling Pond Area and the Administrative Area (see Figure 4-20). The highest concentrations (575 ppm and 500 ppm) were found at SS-58A and SS-58B, respectively. The lowest concentration was 15 ppm, found not far from SS-9, at SS-16 between the arsenic kitchens and the storage bins.

Silver concentrations were highest in the area of the cooling pond: 495 ppm, 503 ppm, and 2075 ppm at SS-58A, SS-58B, and SS-59, respectively. The lowest concentration was 1.3 ppm at SS-39. (Samples collected during the second round of surface soil sampling were not analyzed for silver.)

Selenium concentrations were highest in the arsenic plant and cooling pond areas. The range of selenium concentrations was 9 to 274 ppm. (Round 2 samples were not analyzed for selenium.)

Thallium concentrations were at or below the detection limits at all but 7 sampling stations. The highest concentrations were found in the Site Stabilization Area near the arsenic plant and the cottrells. The detected levels ranged from 13 to 43 ppm. (Round 2 surface soil samples were not analyzed for thallium.)

Barium concentrations were highest in the cooling pond area. The range of concentrations was 70 ppm to 1528 ppm. (Barium was not an analyte for Round 2 samples.)

## 4.3.2 EP TOXICITY (EPTOX) TEST FOR METALS

Results of the EPTox test for metals are presented in Volume 2, Appendix I - Surficial Soils. EPTox analysis of chromium and silver did not exceed the detection limit for any sampling stations. Arsenic concentrations were highest at SS-2, SS-20 and SS-27 (in the area of the arsenic plant). Mercury concentrations ranged from below the detection limit to 1.9 ppm. Cadmium concentrations were highest near the godfrey roasters (1.0 - 1.5 ppm). Lead concentrations were highest (1.3 - 1.6 ppm) in the cooling pond area. Selenium concentrations were highest in an area just north of the pipe treater (4.2 - 8.3 ppm at SS-24, SS-25, SS-26). Barium levels were at or below detection limits for most of the sampling stations. The highest barium concentrations were found in the cooling pond area (1.0 ppm). The pH of samples ranged from 3.7 (near the arsenic kitchen, SS-9B) to 8.6 (cottrell treater area, SS-34). Twenty-eight of 45 samples of soil from the area of site stabilization were RCRA regulated hazardous waste and designated dangerous wastes under WAC 173-303 on the basis of the arsenic EPTox test.

#### 4.3.3 BASE NEUTRAL ORGANICS

Complete analytical results for base neutral organics detected at each sampling station are shown in Volume 2 - Technical Data. See Figure 4-10 for location of sampling stations. In general, the highest concentrations of base neutral organics were found near the former arsenic plant, arsenic kitchens, cottrells, and godfrey roasters in the Site Stabilization Area.

Of the base neutral organics of concern, only dichlorobenzene was not detected. Dibenzofurans were detected in the range of 450 to 7200 ppb. These concentrations were found in the cottrell area and adjacent to the arsenic plant.

Phthalate esters were detected at four sampling stations. Bis (2-ethylhexyl) phthalate was detected at concentrations of 430 and 530 ppb at two sites. Dimethyl phthalate was detected at concentrations of 1520 and 430 at two different sites.

Low molecular weight polycyclic aromatic hydrocarbons (LPAH) detected in the surficial soil samples included: acenaphthene, fluorene, naphthalene, phenanthrene, anthracene, and acenaphthylene. Phenanthrene was detected at the largest number of sampling stations, ranging from 490 to 265,000 ppb. The highest concentration was at SS-21, located along the flues just north of the treaters. Acenaphthylene was detected at only three sampling stations. The other low molecular weight LPAHs were detected at 10 to 31 sampling stations each.

High molecular weight PAHs (HPAHs) detected in the surficial soil samples included: benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, pyrene, and benzo(k)fluoranthene. Dibenzo(a,h)anthracene and benzo(k)fluoranthene were detected at only one sampling station each. The range of concentrations for all high molecular HPAHs was 430 to 277,000 ppb. The highest concentrations were as follows:

SS-21
72,000 ppb benzo(a)pyrene
41,000 ppb benzo(g,h,i)perylene
112,000 ppb chrysene
108,000 ppb benzo(a)fluoranthene
60,000 ppb benzo(b)fluoranthene
169,000 ppb fluoranthene
39,000 ppb indeno(1,2,3-cd)pyrene
277,000 ppb pyrene
SS-2
79,300 ppb pyrene
39,700 ppb benzo(b)fluoranthene

Other base neutral organics were included in the analysis. Results are summarized below:

2-methylnaphthalene 12 sampling stations 520-36,000 ppb 3-nitroaniline 3 sampling stations 2,560-11,900 ppb 2,6-dinitrotoluene 1 sampling station 610 ppb benzidine 1 sampling station 520 ppb isophorone 1 sampling station 560 ppb 1,2,4-trichlorobenzene 2,000 ppb 1 sampling station

#### 4.3.4 ACID EXTRACTABLE ORGANICS

Analytical results for acid extractable organics detected for each sampling station are shown in Volume 2 - Technical Data. See Figure 4-10 for the locations of the sampling stations. Of the acid extractable organics of concern, 2-methylphenol, 4-methylphenol, and 1-methyl(2-methylethyl)benzene were not detected. Dibenzothiophene was detected at 9 stations, ranging from 0.5 to 1,400.0 ppb. Methylphenanthrenes were detected at 22 sampling stations, ranging from 1.4 to 10,600 ppb. Biphenyls were detected at four sampling stations, ranging from 10 to 400 ppb.

#### 4.3.5 OTHER ANALYSES

The results of surficial soils analyses for radiological parameters (uranium, radium-276, and gross alpha) are presented in Volume 2 - Technical Data. Gross alpha results ranged from below the detection limits to 13.0 pCi/g. Uranium concentrations ranged from undetected to 2.36  $\mu$ g/g. Radium-226 levels ranged from undetected to 7.02 pCi/g.

Dimethylaniline was not detected at any sampling stations. The pH values for soil samples at each station are included in Volume 2 - Technical Data. The range detected was 3.7 to 8.6.

PCBs were detected at nine sampling stations (see Volume 2 - Technical Data for PCB results). The detected PCB concentrations ranged from 1,000 ppb to 4,720 ppb. These concentrations were detected at the following station:

SS-10, SS-20, SS-31B, SS-32, SS-33, SS-38, SS-43 and SS-MW4-S-1.

## 4.3.6 ARSENIC WITH DEPTH

Seven surface soil samples collected during Round 2 of the field investigation were analyzed for arsenic at three depths: 3 to 4 inches, 6 to 7 inches and 11 to 12 inches. Sample SS2-05, collected from the bottom of the cooling pond, shows an increase with depth in arsenic concentration from 182 ppm to 3,025 ppm. The remaining samples that were collected were from off-site. Samples SS2-12 and SS2-18 show arsenic concentrations that remain relatively constant at all depths. The rest of the samples (SS2-06, 14, 21 and 24) show decreasing concentrations of arsenic with depth.

## 4.4 SUBSURFACE SOIL AND SLAG

# 4.4.1 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION IN SUBSURFACE SOIL AND SLAG

### 4.4.1.1 Total and EPTox Metal Results

A total of 91 soil and slag samples were analyzed for total metals. EPTox metal analysis was performed on 67 soil and slag samples. A summary of results are presented in Appendix J - Subsurface Soils.

- Total arsenic, barium, chromium, copper, lead, nickel, and zinc were detected in all subsurface soil and slag samples. Total metal concentrations were generally much higher in slag than they were in granular fill.
- Arsenic, cadmium, lead, copper, and zinc were the only EPTox metals detected in more than one soil or slag sample. Native soil samples typically contained much lower EPTox metal concentrations than slag or granular fill samples.
- The highest average EPTox arsenic concentrations were detected in granular fill.
- Slag EPTox results may be positively biased due to the crushing of slag samples during drilling and sampling activities.
- Granular fill and slag total and EPTox metal concentrations were extremely variable.
- Total and EPTox metal concentrations do not appear to be correlated within a subsurface soil or slag matrix.

#### 4.4.1.2 Petroleum Occurrences

Petroleum was detected in subsurface soils and slag samples collected in the northeastern portion of the plant near the Fine Copper Casting Building. Petroleum was also detected in soils collected from MW-8.

- Total petroleum hydrocarbons concentrations ranged from 150 to 5,700 ppm in samples collected from boring B-3A and monitoring wells B-14, B-33, B-36, MW-8, and MW-9. The highest petroleum concentrations were detected in B-36.
- Benzene and toluene were not detected in subsurface soils or slag. Ethylbenzene (55 ppb) and xylenes (110 ppb) were detected in B-36.
- No PCBs were detected in soil or slag samples containing petroleum products.
- Petroleum detected in subsurface samples appears to be a highly weathered mixture of diesel and bunker C fuel oils.

## 4.4.1.3 Dimethylaniline Occurrences

Dimethylaniline (DMA) was used in the production of liquid sulfur dioxide in the southeast portion of the Asarco facility. Approximately 50 soil and slag samples from various borings across the site were analyzed for DMA.

- DMA was detected only in soil or slag samples collected from B-36, B-37, and B-16, which are near the DMA storage area.
- DMA concentrations in B-37 ranged from not detected to 812 ppm. The concentration of DMA in B-16 (23 to 24.5 ft) was 4.9 ppm.

## 4.4.2 INTRODUCTION

To evaluate the quality of subsurface soil and slag, approximately 120 samples collected from borings shown on Figure 3-10 were submitted for chemical analysis. Samples collected in Phase I were analyzed for total metals, semivolatile organic compounds, total halogenated hydrocarbons, PCBs, and radiological parameters.

Most samples collected in Phase II were analyzed for total and EPTox metals. Soil and slag samples collected in areas of petroleum contamination were typically analyzed for total petroleum hydrocarbons (TPH) and semivolatile organic compounds (including n,n-dimethylaniline, 1-methyl (2-methylethyl) benzene, biphenyl, retene, dibenzothiophene, 1-methylphenanthrene, 2-methylphenanthrene, and 1-methylpyrene). Selected samples suspected of containing high petroleum concentrations were also analyzed for volatile aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylenes), polychlorinated biphenyls (PCBs), and GC-FID fuel fingerprinting.

Soil and slag samples collected near the dimethylaniline storage area at the south end of the facility were typically analyzed for semivolatile organic compounds. Subsurface soil and slag quality are summarized in Volume 2, Appendix J. Data validation results and analytical methods are discussed in Section 2.2 (Volume 3).

## 4.4.3 INORGANICS

Soil and slag samples were analyzed for total and EPTox metals, as well as several radiological parameters. Alpha particles, uranium, and radium-226 were detected in both soil and slag samples. Alpha particle and radium-226 levels ranged from not detected to 4.6 pCi/g. Uranium concentrations ranged from not detected to 2.11  $\mu$ g/g. Radiological data is summarized in Appendix J. Total and EPTox metal results are discussed in the following sections.

## 4.4.3.1 Total Metals Results

Total and EPTox metal sample results for all soil and slag samples are summarized in Table F-3 in Appendix F - Technical Data Summaries. Metal results for slag, granular fill, and native soils are summarized in Tables F-4 through F-6. Subsurface soil characteristics and distribution are discussed in Section 3.5.2. In order to calculate the mean of total and EPTox metal concentrations, detection limits were used as values for metal results reported as not detected. The upper 95th percent quantile was calculated assuming a "t" distribution for metal concentrations.

All 13 of the metals analyzed for total analysis were detected in at least 14 soil or slag samples. Arsenic, barium, chromium, copper, lead, nickel, and zinc were detected in all subsurface soil and slag samples. Total metal concentrations were generally higher in slag versus granular fill and native soil samples. The average total arsenic concentration for all slag samples was 4,837 ppm. Average total arsenic concentrations in granular fill and native soils were 1,043 ppm and 33 ppm, respectively. However, the average concentration of cadmium in granular fill was higher than slag. Histograms showing metal frequency distributions for all samples and the three soil matrices are presented on Figures 4-21 through 4-26.

#### 4.4.3.2 EPTox Results

Despite the elevated total metal concentrations in many of the subsurface soil and slag samples, only six of the ten metals analyzed for EPTox were detected in any of the samples. Mercury was detected in only one sample. EPTox results indicate that arsenic, cadmium, lead, copper, and zinc are the only metals analyzed that exhibit some degree of leachability (under the conditions of the test procedure) in Asarco subsurface soil and slag samples. As shown on Figures 4-27 through 4-32, most of the detected metal values were near the detection limit. EPTox arsenic was not detected in native soils. Native soils typically contained much lower EPTox concentrations than slag and granular fill. Lead, copper, and zinc average concentrations were highest in slag samples. The highest average arsenic and cadmium EPTox concentrations were detected in granular fill

samples. Average concentration values for subsurface soils and slag are presented in Appendix F.

EPTox concentrations in slag samples may be positively biased due to the drilling methods used for sample collection. In order to penetrate massive slag, ODEX drilling equipment crushed and pulverized the slag. Hollow-stem auger drilling also crushed the slag samples. Crushing of slag provides fresh surfaces, which greatly increases metal leachability (Crecelius 1986). The importance of subsurface soil and slag EPTox concentrations in predicting leaching of trace metals into groundwater will be discussed in Section 4.6.

# 4.4.3.3 Total and EPTox Metal Spatial Distribution

Figures 4-33 through 4-44 present total and EPTox data for arsenic, copper, lead, and zinc at three selected depth ranges (0 to 10 ft, 10 to 25 ft, and >25 ft). Metals concentrations in the subsurface were extremely variable spatially and with depth. Both slag and soil samples exhibited a wide range of trace metal composition and leachability. Figures 4-33 through 4-44 illustrate and spatial variability of the subsurface metals data. For example, total arsenic concentrations in slag samples collected in the 0- to 10-ft depth interval ranged from 53 ppm at boring B-3A to 9,000 ppm at monitoring well B-36. B-3A and B-36 are approximately 150 ft apart.

Metal concentrations in a given depth interval varied depending on the matrix. Slag and granular fill metal concentrations were generally much higher than native soils. Total arsenic concentration in the 0- to 10-ft-depth interval at monitoring well B-23 ranged from 2,575 to 11,000 ppm. The arsenic concentration at the same depth interval in boring B-24 was 29 ppm. B-23 and B-24 are both located at the arsenic kitchen area and are less than 400 ft apart. Samples collected in B-23 were composed of granular fill whereas native soils were sampled in B-24.

The highest metal concentrations in granular fill generally occurred in samples collected from B-23 (arsenic kitchen area), B-18 (south of stack), and B-29 (northeast corner of parking lot). Based on data produced by this work, the trace metal composition of granular fill is very heterogeneous.

## 4.4.3.4 Total and EPTox Concentrations Vertical Distribution

Vertical distributions of metal concentrations in subsurface slag and granular fill samples are summarized in Tables F-7 through F-12 (Appendix F - Technical Data Summaries). Based on data presented in these tables, total and EPTox concentrations generally appear to decrease with depth. However, there are exceptions to this trend. The relationship between sample depth and subsurface soil and slag metal concentrations were evaluated statistically using correlation matrices and linear regression. No significant correlation was observed ( $r^2 < 0.5$ ). It does appear, however, that near-surface (0- to 10-ft-depth interval) slag and granular fill samples generally contain the highest total and EPTox metals concentrations.

## 4.4.3.5 pH of Soil and Slag

Measurements for pH were conducted in the field by Asarco's Salt Lake City laboratory. Results are presented on the subsurface exploration logs in Appendix B. The pH of soils typically ranged from 5 to 9. Soil or slag samples collected in B-16 (0 to 5 ft), B-23 (0 to 1.5 ft), MW-1A2 (0 to 10 ft), and MW-5 (61 to 62 ft) had pH values between 4 and 5.

# 4.4.3.6 Comparison of Total and EPTox Metal Concentrations

Total metal and EPTox metal concentrations do not appear to be correlated. Although slag generally contains much higher total metal concentrations than granular fill, their EPTox metal concentrations are relatively similar. In addition, higher total metal concentrations in soil and slag samples often do not result in higher EPTox concentrations. The relationship between total and EPTox metal concentrations was evaluated statistically using linear regression.

Correlation coefficients (r<sup>2</sup>) were determined for arsenic, cadmium, copper, lead, and zinc for all soil and slag samples. The correlation between total and EPTox metal concentrations was also evaluated for granular fill and slag samples individually.

Total versus EPTox metal correlation coefficients were typically below 0.5 for combined soil and slag samples, except copper which was 0.623. Correlation coefficients for slag samples were below 0.5, except for copper (0.53). Arsenic (0.847) and lead (0.675) correlation coefficients were above 0.5 in granular fill samples. However, these values for arsenic and lead are suspect due to the small data set and small number of detectable EPTox concentrations. Based on this statistical evaluation, it appears that there is little correlation between total and EPTox metal concentrations for soil or slag samples.

#### 4.4.4 ORGANICS

Subsurface soil and slag samples collected during Phase I sampling were analyzed for semivolatile organic compounds, total halogenated hydrocarbons, and PCBs. Approximately 50 soil samples collected during Phase II sampling were analyzed for semivolatile organic compounds. Selected samples collected in areas of known petroleum occurrences were also analyzed for one or more of the following analyses: volatile aromatic compounds (BTEX), total petroleum hydrocarbons (TPH), PCBs, and GC-FID fuel fingerprinting.

No semivolatile organic compounds were detected in Phase I samples except bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate concentrations ranged from not detected to 1.8 ppm. Bis(2-ethylhexyl)phthalate and/or di-n-butylphthalate were detected in six Phase II samples at concentrations ranging from 0.44 to 1.02 ppm. However, phthalate esters are commonly used as plasticizers and are often introduced to samples in the laboratory or from sampling equipment or containers.

Polynuclear aromatic hydrocarbons (PAH) were detected in Phase II samples collected from B-18 (0 to 1.5 ft) and B-23 (0 to 1.5 ft) at concentrations ranging from 0.40 to 2.83 ppm. PAH compounds were also detected in soil or slag samples collected in areas of dimethylaniline or petroleum occurrences. Dimethylaniline and petroleum occurrences will be discussed in Sections 4.4.4.1 and 4.4.4.2.

Halogenated hydrocarbons were not detected in subsurface soils except in boring B-3A (10 to 13 ft) at a concentration of 210 ppm. No PCBs were detected in Phase I or Phase II samples.

## 4.4.4.1 Petroleum Occurrences

Petroleum was detected in subsurface soil and slag samples collected in the northeastern portion of the plant at sampling locations B-3A (24 to 33 ft), B-14 (13 to 26 ft), B-33 (20 to 40 ft), and B-36 (5 to 15 ft). Petroleum was also detected in monitoring well MW-8 (2.5 to 16.5 ft) located east of the acid plant. Selected samples were analyzed for total petroleum hydrocarbons (TPH), semivolatile organic compounds, and volatile aromatic compounds (BTEX). A summary of these results is presented in Volume 2, Appendix J - Subsurface Soils.

## Total Petroleum Hydrocarbons (TPH)

TPH analysis was performed on 31 soil and slag samples. TPH results below 150 ppm were considered not detected due to their elevated TPH blank concentrations (see Volume 3, section 3.8.5 for a more detailed explanation). Petroleum hydrocarbons were detected in 9 of 31 samples at concentrations ranging from 150 to 5,700 ppm. The highest TPH concentration was detected in B-36 at a depth of 12.5 to 14 ft.

#### Volatile Aromatic Compounds (BTEX)

BTEX compounds are commonly associated with various petroleum products including gasoline and bunker C oil. BTEX compounds are fairly soluble in water and are often the main petroleum constituents that can affect groundwater quality. Samples were selected for BTEX analysis based on field volatile organic measurements using a portable photoionization detector (H-Nu Model P1-101 equipped with a 10.2 eV lamp) and sample odor. BTEX compounds were not detected in samples collected from B-14 and B-33. Ethylbenzene (55 ppb) and xylenes (110 ppb) were detected in B-36 at a depth of 12.5 to 14 ft.

### Semivolatile Organic Compounds

Several semivolatile organic compounds were detected in slag samples collected from B-36 (0 to 5 ft), B-36 (12.5 to 14 ft), MW-8 (2.5 - 4 ft), and B-3A (29.5 - 32.5 ft). Chrysene and benzo(b)fluoranthene, which are polynuclear aromatic hydrocarbons (PAH), were detected in B-36 (0 to 5 ft) at concentrations of 0.34 and 0.41 ppm, respectively. Eight PAH compounds were detected in B-36 (12.5 to 14 ft) at concentrations ranging from 0.40 to 2.59 ppm. Nine PAH compounds were detected in MW-8 at estimated

concentrations ranging from 0.54 to 1.23 ppm. PAH compounds detected in B-36 and MW-8 are often associated with petroleum (Verschueren 1983). Pyrene and bis(2-ethylhexyl)phthalate were detected in B-3A at estimated concentrations of 0.44 and 0.55 ppm, respectively. Pyrene is also a PAH compound and was probably derived from petroleum (Verschueren 1983).

Samples containing petroleum product from B-33 (30.5 to 31.5 ft) and B-36 (12.5 to 14 ft) were analyzed for PCBs and chlorinated pesticides. No PCBs were detected. Alpha-BHC, a chlorinated pesticide, was detected in both samples at a concentration of 0.022 ppm. The detection limit for alpha-BHC was 0.010 ppm.

#### GC-FID Fuel Fingerprint

GC-FID fingerprint analysis was performed on soil and slag samples collected from B-14, B-3A, B-36, MW-8, and MW-9. The chromatographic peak pattern identified from B-36 was similar to a weathered mixture of diesel and bunker C fuel oil. The petroleum peak patterns identified in B-14, B-3A, and MW-8 soils also appear to be mixtures of diesel and bunker C but are more severely weathered. Weathering of petroleum, caused by either volatilization or flushing with water, results in the removal of lighter molecular weight hydrocarbons which tend to be more mobile. The high degree of weathering indicates that petroleum in both the northeast portion of the site and at MW-8 have been exposed to groundwater flow for an extended period of time.

The TPH result for soils collected from MW-9 (10 to 11.5 ft) was estimated at 150 ppm. The corrected detection limit for TPH was also 150 ppm. GC-FID fingerprint analysis of this sample did not detect any petroleum hydrocarbons.

## 4.4.4.2 Dimethylaniline Occurrence

N,N-Dimethylaniline (DMA) is typically a tan-to-brown colored liquid with a strong "amine-like" odor. It is insoluble to slightly soluble in water and is somewhat volatile (vapor pressure is 1 mm at 29.5°C). The density of DMA is slightly less than water (0.997). DMA was used in the production of sulfur dioxide at the SO<sub>2</sub> Plant located in the southeast portion of the Asarco facility. The DMA storage area was located just east of the SO<sub>2</sub> Plant.

DMA was included in all semivolatile organic analyses conducted in Phase II. It was detected only in soils or slag collected from B-37 and B-16 (23 to 24.5 ft). DMA concentrations in B-37 ranged from not detected (0 to 5 ft) to 812 ppm (10.5 to 12 ft). Acenaphthene (0.34 ppm), N-nitrosodiphenylamine (0.51 ppm), and phenanthrene (0.68 ppm) were also detected in B-37 (10.5 to 12 ft). DMA concentration in B-16 was 4.9 ppm. Fluoranthene (0.60 ppm) and retene (2.3 ppm) were also detected in B-16 (23 to 24.5 ft).

#### 4.5 GROUNDWATER

# 4.5.1 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION IN GROUNDWATER

#### 4.5.1.1 Total and Dissolved Metals

A total of 59 groundwater samples were collected for metal analysis from 28 monitoring wells and two seeps. The cooling pond and seawater were also sampled. Groundwater quality and analytical methods are summarized in Volume 2, Appendix K - Groundwater.

- Arsenic, copper, and zinc were detected in over 90 percent of the samples collected for total metals analysis. Antimony, selenium, silver, thallium, and mercury were detected in less than 25 percent of the samples collected. Total arsenic concentrations ranged from not detected to 30,600 ppb.
- Arsenic, copper, and zinc were detected in over 75 percent of the samples collected for dissolved metal analysis. Dissolved chromium and silver were not detected. Antimony, barium, selenium, thallium, and lead were detected in less than 20 percent of the groundwater samples. Dissolved arsenic ranged from not detected to 30,600 ppb.
- The highest metal concentrations were detected in the plant area. The average arsenic, copper, and zinc concentrations in the plant area were approximately one to two orders of magnitude greater than the stack and parking lot areas. The average total and dissolved arsenic concentrations in the parking lot area were 6,503 ppb and 5,304 ppb, respectively.
- No obvious relationship was observed between groundwater metal concentrations and tidal cycles.

#### 4.5.1.2 Petroleum Occurrences in Groundwater

Petroleum was detected in soils collected in the northeastern portion of the plant and in MW-8. Groundwater in these areas was analyzed for the presence of petroleum.

- Free floating petroleum product was not detected in any monitoring wells. A sheen was observed on top of water removed from monitoring well B-36.
- Petroleum hydrocarbons were detected only in monitoring well B-36. BTEX compounds were generally not detected.
- Petroleum in subsurface soils appears to have very limited mobility. It is doubtful that a significant flux of petroleum hydrocarbons is entering Commencement Bay based on these subsurface petroleum occurrences.

#### 4.5.1.3 Dimethylaniline Occurrences in Groundwater

N,N-dimethylaniline (DMA) was detected in subsurface soils or slag collected from B-37 and B-16. A total of 14 groundwater samples were analyzed for the presence of DMA.

- DMA was detected in groundwater samples collected B-37 (150,000 ppb) and B-36 (44 ppb). DMA was tentatively identified in MW-1A2. DMA was not detected in any other groundwater samples including samples from B-16.
- N-methylaniline and aniline were also detected in samples containing DMA.

#### 4.5.2 INTRODUCTION

To evaluate groundwater quality, a total of 59 samples were collected for chemical analysis from 28 monitoring wells and two seeps. The cooling pond and Commencement Bay seawater were also sampled. Groundwater sampling locations are shown on Figure 3-10.

Samples collected in Phase I were analyzed for total and dissolved metals, semivolatile organic compounds, PCBs, and radiological parameters. Phase II groundwater samples were analyzed for total and dissolved metals, total organic carbon, and major inorganic ions.

Groundwater samples collected in areas of petroleum contamination were typically analyzed for total petroleum hydrocarbons (TPH), volatile aromatic compounds (BTEX), and semivolatile organic compounds. The semivolatile compounds include n,n-dimethylaniline, 1-methyl (2-methylethyl) benzene, biphenyl, retene, dibenzothiophene, 1-methylphenanthrene, 2-methylphenanthrene, and 1-methylpyrene. Groundwater samples collected near the dimethylaniline storage area at the south end of the facility were analyzed for volatile and semivolatile organic compounds.

Groundwater quality and analytical methods are summarized in Volume 2 - Appendix K. Table B-1 (Appendix B) summarizes groundwater parameters measured in the field (pH, electrical conductivity, temperature, dissolved oxygen, and salinity).

#### 4.5.3 INORGANICS

Groundwater samples were analyzed for total and dissolved metals, major ions, and several radiological parameters. Groundwater samples collected along the eastern portion of the Asarco facility contained high concentrations of sodium, chloride, sulfate, and bicarbonate compared to samples collected along the western portion of the site. These ion concentrations decreased by several orders of magnitude in samples collected farther west away from Commencement Bay. Groundwater collected in monitoring wells MW-3A2, MW-3B, and B-33 contained similar major ion concentrations as those in Commencement Bay seawater collected at the tidal station. Field measurements of

electrical conductivity and salinity indicate that groundwater in this portion of the plant is very saline (17 to 25 ppt).

Groundwater collected from the southeast portion of the facility contained elevated sulfide concentrations as compared to the stack and parking lot areas. Sulfide concentrations in this area ranged from not detected (MW-1B) to 2.9 ppm (MW-1A2). The stack and parking lot areas generally had similar major ion concentration distributions.

Alpha particles and radium-226 were not detected except in MW-3B at levels of 22.0  $(\pm 16)$  and 11.8  $(\pm 5.9)$  pCi/gram, respectively. Uranium concentrations ranged from not detected to 0.009  $\mu$ g/g.

Total and dissolved metal results are discussed in the following sections. In this report, dissolved metals are defined as those metals which passed through a 0.45  $\mu$  filter.

#### 4.5.3.1 Total and Dissolved Metals Results

Total and dissolved metal results for all groundwater samples are summarized in Table F-13 presented in Appendix F. Metal results for the parking lot, stack area, and plant area groundwater regimes are summarized in Tables F-14 through F-16. In order to calculate the mean of total and dissolved metal concentrations, detection limits were used as values for metal results reported as not detected. The upper 95th percent quantile was calculated assuming a "t" distribution for metal concentrations.

#### 4.5.3.2 Total Metal Concentration Distributions

All 16 of the metals analyzed for total analysis were detected in at least three groundwater samples. Iron, magnesium, and manganese were the only metals detected in all samples. Arsenic, copper, and zinc were detected in over 90 percent of the samples collected. Antimony, selenium, silver, thallium, and mercury were detected in less than 25 percent of the samples collected. The metals with the highest total concentrations were generally arsenic, copper, zinc, iron, magnesium, and manganese. Total arsenic concentrations ranged from not detected to 30,600 ppb. Histograms showing total metal frequency distributions for all samples and the three groundwater regimes are presented on Figures 4-45 through 4-53. As shown in the histograms, most of the groundwater metal concentrations values were below or near the detection limit. However, a wide range of metal concentration values were observed for most metals especially arsenic, copper, iron and zinc.

#### 4.5.3.3 Dissolved Metal Concentration Distributions

Dissolved chromium and silver were not detected in any samples. Antimony, barium, selenium, thallium, and lead were detected in less than 20 percent of the samples analyzed for dissolved metals. Dissolved arsenic, copper, and zinc were detected in over 75 percent of the samples. The metals with the highest dissolved concentrations were generally arsenic, copper, and zinc. Dissolved arsenic concentrations ranged from not

detected to 30,600 ppb. Histograms showing dissolved metal frequency distributions for all samples and the three groundwater regimes are presented on Figures 4-45 through 4-62. Most dissolved metal concentration values were also below or near detection limits and exhibited wide concentration ranges.

#### 4.5.3.4 Comparison of Dissolved and Total Metal Concentrations

Dissolved metal concentrations were generally lower than total metal concentrations. Due to analytical and sampling variability, several dissolved metal concentrations were slightly above total concentrations. Most of the monitoring wells sampled had substantially higher total metal concentrations as compared to dissolved concentrations due to higher suspended solids concentrations in unfiltered versus filtered samples. Preservation with acid causes metals attached to the suspended solids to dissolve into the water phase. Many of the monitoring wells at the Asarco site were screened in fairly fine-grained materials. Groundwater in these wells were generally turbid despite repeated attempts to remove particulates during well development and purging activities. Although every effort was made to collect groundwater samples with total suspended solid levels typical of true aquifer conditions, many samples were fairly turbid due to sampling activities. In general, dissolved metal concentrations are more representative of actual metal concentrations in groundwater migrating through soil materials.

#### 4.5.3.5 Total and Dissolved Metal Spatial Distribution

Groundwater in the plant area generally contained the highest metal concentrations. The average arsenic, copper, and zinc concentrations were approximately one to two orders of magnitude greater in the plant area than the stack and parking lot areas (see Appendix F, Tables F-14 to F-16). The stack and parking lot areas contained similar concentration distributions for most metals. However, the average arsenic concentrations in the stack area were approximately one order of magnitude greater than in the parking lot area.

The spatial distribution of total and dissolved arsenic, copper, and zinc in groundwater samples collected as part of Phase II sampling are presented on Figures 4-63 and 4-66. The highest arsenic concentrations in the fill aquifer were detected in the eastern portion of the plant area including monitoring wells MW-1A2, MW-2A, MW-2B, MW-3A2, and B-37. Total and dissolved arsenic concentrations in the plant area ranged from not detected to 30,600 ppb. Copper and zinc concentrations were also highest in the eastern portion of the fill aquifer.

The spatial distribution of arsenic, copper, and zinc in Phase II samples was similar to Phase I samples. In both sampling events, there was a substantial difference in metal concentrations detected in MW-1A2 and MW-1B. Arsenic concentrations in MW-1A2 were an order of magnitude higher than MW-1B. MW-1B contained much higher concentrations of copper and zinc. MW-1A2 and MW-1B were located within 10 ft of each other and were both screened in the granular slag unit of the fill aquifer. The bottom of the screen in MW-1A2 was approximately 10 ft below the screen bottom in MW-1B.

The difference in metal concentrations between MW-1A2 and MW-1B may be due to the presence of wood waste fill. During well installation, wood chips and hydrogen sulfide odor were observed just beneath the screened interval in MW-1A2. Sulfide released from the wood waste may cause several metals, including copper and zinc, to precipitate as metal sulfides. The observed differences in concentrations between MW-1A and MW-1B may be the result of this influence.

Cadmium and total lead concentrations were generally highest in the southeast portion of the site. Dissolved lead was detected only in B-36 (38 ppb). The highest total chromium concentrations were detected in monitoring wells MW-5, MW-9, and MW-12. Dissolved chromium was not detected at any of the sampling locations. Nickel concentrations were highest in monitoring wells B-34, B-36, MW-4, and MW-12.

Most total metals were not detected in monitoring well B-14, which was screened in the deeper Pre-Vashon Sand aquifer. Arsenic and copper concentrations in B-14 were 9 ppb and 19 ppb, respectively. In the seawater sampled at the tidal station located on the northern dock, most metals were below or near the detection limit. Arsenic, copper, and zinc were detected in the cooling pond water sample. These concentration levels were below the average stack area concentrations for arsenic, copper, and zinc.

Spring 1, which is located south of the ASARCO stack, contained detectable concentrations of total arsenic (313 ppb), barium (220 ppb), cadmium (1 ppb), copper (234 ppb), and zinc (34 ppb). Spring 2, which is located west of the stack, contained detectable concentrations of total arsenic (300 ppb), cadmium (1 ppb), chromium (30 ppb), copper (368 ppb), and zinc (74 ppb). Metal concentrations in the spring samples were similar to groundwater samples collected in the stack area.

#### 4.5.3.6 Influence of Tidal Cycles on Metal Concentrations

Tidal sampling was conducted to evaluate the influence of tidal cycles on groundwater chemistry. Three sets of nested wells adjacent to Commencement Bay were used for tidal sampling: MW-1A2/MW-1B, MW-2A/MW-2B, and MW-3A2/MW-3B. Samples were collected at low, medium, and high tides in all six wells on October 19, 1988. MW-3B was dry except during high tide. A summary of groundwater results is included in Volume 2 - Appendix K.

No obvious relationship was observed between tidal cycles and groundwater metal concentrations. Variations in metal concentrations observed between samples collected during low, medium, and high tides are probably due to sampling and analytical variability. While some metal concentrations increased, other metals decreased in concentration. In addition, no trends in major ion concentrations were observed.

#### 4.5.4 ORGANICS

Samples collected in Phase I were analyzed for semivolatile organic compounds and PCBs. Phase II groundwater samples were routinely analyzed for total organic carbon. Groundwater samples collected in areas of petroleum contamination were typically analyzed for total petroleum hydrocarbons (TPH), volatile aromatic compounds (BTEX), and semivolatile organic compounds (including n,n-dimethylaniline, 1-methyl (2-methylethyl) benzene, biphenyl, retene, dibenzothiophene, 1-methylphenanthrene, 2-methylphenanthrene, and 1-methylpyrene). Groundwater samples collected near the dimethylaniline storage area at the south end of the facility were analyzed for volatile and semivolatile organic compounds.

No semivolatile organic compounds were detected in Phase I or II samples except for bis(2-ethylhexyl)phthalate in sample MW-5 (10 ppb) and dimethylaniline. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant. Dimethylaniline occurrences will be discussed in Section 4.5.4.2. Total organic carbon (TOC) levels ranged from not detected to 260 ppm (B-37). Elevated TOC concentrations were also observed in B-25 (5.7 ppm) and MW-12 (21 ppm).

#### 4.5.4.1 Petroleum Occurrences

Petroleum was detected in subsurface soil and slag samples collected in the northeastern portion of the plant at sampling locations B-3A, B-14, B-33, and B-36. Petroleum was also detected in subsurface soils collected from MW-8 located east of the acid plant. Free floating petroleum product was not detected in any of the wells. A sheen was observed on top of water removed from monitoring well B-36.

Total petroleum hydrocarbons were detected at a concentration of 40 ppm in B-36. TPH was not detected in B-33, B-34, or B-37. BTEX compounds were generally not detected. Toluene was detected in B-33 (1 ppb) and B-36 (2 ppb). Based on the lack of petroleum hydrocarbons in groundwater (except B-36), it appears that petroleum in subsurface soils has very limited mobility. GC-FID fingerprints of the petroleum indicate that it is predominately a highly weathered, fairly heavy fuel oil. In addition, the aqueous solubility of petroleum would be decreased further due to the high salinity in groundwater adjacent to the bay. It does not appear that a significant flux of petroleum hydrocarbons would enter Commencement Bay as a result of these subsurface petroleum occurrences.

### 4.5.4.2 Dimethylaniline Occurrences

DMA was detected in soils or slag collected from B-37 and B-16. A sheen and strong odor was observed in water removed from monitoring well B-37, which was located next to the DMA storage area. No free product layers were detected in B-37. DMA is less dense than water and should float on top of groundwater. However, since most of the wells in the southeastern portion of the plant were not screened across the water table (including B-37), the presence of floating DMA product was difficult to assess.

DMA was detected in groundwater samples collected from B-37 (150,000 ppb) and B-36 (44 ppb). DMA was also detected below the sample detection limit in MW-1A2 at an estimated concentration of 4 ppb. Aniline (86,000 ppb) and n-methylaniline (650 ppb) were also tentatively identified in B-37. N-methylaniline was also tentatively identified in B-36 (230 ppb) and MW-1A2 (32 ppb). All n-methylaniline and aniline concentrations were estimated.

The presence of DMA in monitoring well B-36 was unexpected. DMA was only used in the southeast portion of the plant at the sulfur dioxide plant. One possible explanation for the DMA occurrence in B-36 was due to the leaking of DMA-containing wastewater in the number one and number two refineries. Wastewater in the southeast portion of the plant was pumped to the basements of the refinery buildings for treatment. Although the floors were lined with concrete, it is possible that wastewater containing some DMA could seep through cracks in the floor and eventually enter groundwater in the northeast portion of the plant (Dungey 1989 personal communication). The treatment of wastewater in the refinery buildings has been discontinued. DMA was not detected in any other wells in this area.

Based on tentative DMA results in MW-1A2, it appears that some DMA may be migrating towards the bay. DMA is not soluble in water (Windholz 1983). DMA may adsorb onto mineral or organic matter surfaces and be transported as a particulate. However, particulate transport in groundwater should be minimal. The primary mechanism for DMA transport in water should be flow of free floating product (if present).

# 4.6 FILL/SLAG LEACHING

#### 4.6.1 SUMMARY OF FILL LEACHATE TESTING RESULTS

Five leaching tests were conducted by Hart Crowser to assess the leaching potential of trace metals to water from Asarco slag and granular fill. Leaching tests were performed on granular fill and slag samples obtained from various areas within the project site. A variety of tests were performed, including analyses for total and extraction procedure (EPTox) metals and column leaching tests described in this section. For consistency, the results are described in parts per million (ppm) units. The results of this testing are summarized below:

- Slag generally had higher total metal content than the granular fill materials that were tested. Total copper, lead, and zinc concentrations were up to 10 times higher in slag. Slag generally also had a higher total arsenic content. However, total arsenic concentration in granular fill within the arsenic kitchen area exceeded the concentration of slag in places. The highest total arsenic concentration of samples tested during this portion of the work was 20,375 ppm from a sample obtained from granular fill underlying the arsenic kitchen area (TP-6).
- Although slag generally has higher total metal concentrations, EPTox and column leaching tests indicated that metals in the granular fill are more leachable than

those in slag. For example, arsenic concentrations in leachate water from granular fill samples (TP-1, TP-3, and TP-6) ranged between 5.3 and 353 ppm as compared to a concentration of 0.061 ppm in the slag sample collected from TP-8. This finding was also supported by a comparison of total and EPTox test results.

- The most leachable materials on the site likely were in the arsenic kitchen area. Samples from this area (TP-3 and TP-6) generally displayed the highest concentrations of arsenic, copper, and zinc in leachate water.
- Our leaching test results indicated that granular fill material at the site was the probable source of elevated metals concentrations in groundwater.

### 4.6.2 INTRODUCTION

The purpose of the leaching tests was to evaluate the release of trace metals from granular and slag fill materials located on the Asarco Tacoma site. To assess whether these fill materials may act as sources of metals to groundwater, five leaching tests were done on selected granular fill and slag samples. Granular fill and slag samples were collected from seven test pits at locations shown on Figure 4-65. Test pits were located in areas suspected of containing high metal concentrations. Sampling methodology is discussed in Appendix B.

Test pit granular fill and slag samples were submitted to Asarco's Salt Lake City laboratory for total and EPTox metals analysis. The extraction procedure used to determine total metals in granular fill or slag samples consisted of digesting the solid samples with concentrated nitric acid. Slag and granular fill samples analyzed for EPTox metals were extracted for 24 hours using deionized water adjusted to a pH of 5 with acetic acid.

One slag and four granular fill test pit samples were selected for leachate testing conducted at Hart Crowser's laboratory. Leachate testing consisted of passing pH-adjusted deionized water through a permeameter (Appendix D, Figure D-1) filled with granular fill or slag and then measuring the changes in the water quality. Water was allowed to flow through the granular fill or slag column at a rate of approximately one pore volume per week. Water exiting the permeameter was split into inner-ring and outer-ring outflows. Water outflow in the inner-ring portion of the permeameter was filtered through an in-line 0.45  $\mu$  filter and collected in 4-L plastic sample bottles containing nitric acid preservative. Inner-ring sample bottles were replaced after approximately one-half pore volume of water was collected. A total of five samples were collected from each permeameter and analyzed for dissolved metals. The pH of the outer-ring outflows were measured daily. Leachate testing procedures are discussed in greater detail in Appendix D.

# 4.6.3 LEACHING TEST GRANULAR FILL AND SLAG SAMPLE DESCRIPTIONS

Granular fill and slag samples collected from the seven test pits are described below. Samples from TP-1, TP-3, TP-6, TP-7, and TP-8 were selected for testing. Based on material type, these samples were selected because they represent fill material.

- TP-1 Moist, yellow with white and reddish brown mottling, slightly clayey, gravelly sand (Granular Fill).
- TP-2 Moist, grayish-black, slightly silty sand interbedded with clayey silts that contained decaying organic matter (Granular Fill).
- TP-3 Moist, brown with white and yellow mottling, slightly silty gravelly sand (Granular Fill).
- TP-5 Gray ore, with 20 to 30 percent slag.
- TP-6 Moist, tan with yellow and brownish-red mottling, sandy silt (Granular Fill).
- TP-7 Moist, brown, gravelly sand (Granular Fill) that contained wood and brick fragments.
- TP-8 Dry, gray to black, crushed slag.

Slag was not observed in any of the granular fill samples.

#### 4.6.4 TOTAL METAL AND EPTOX PROCEDURE TEST RESULTS

Total and EPTox metal results for granular fill and slag samples used during the leachate testing are summarized in Volume 2, Appendix L. The highest total arsenic concentrations were detected in granular fill collected from TP-6 (20,375 ppm) in the arsenic kitchen area and slag collected from TP-8 (9,950 ppm). Total copper, lead, and zinc concentrations in the slag sample collected from TP-8 (located next to the Fine Copper Casting building) were up to an order of magnitude greater than the granular fill test pit samples.

The highest EPTox arsenic concentrations were detected in TP-6 (31 ppm) and TP-3 (3.5 ppm). TP-6 and TP-3 were both granular fill samples collected in the arsenic kitchen area. The concentration of EPTox arsenic in the TP-8 slag sample was 0.013 ppm. EPTox copper concentrations ranged from not detected in TP-7 (granular fill) to 4.2 ppm in TP-3 (granular fill). TP-7 was located approximately 150 ft north of the arsenic plant. EPTox zinc concentrations ranged from 0.11 ppm in slag (TP-8) to 2.1 ppm (TP-3 and TP-5). The pH of test pit samples ranged from 4.2 to 6.4 in granular fill samples collected from TP-6 and TP-7, respectively.

#### 4.6.5 LEACHATE WATER DISSOLVED METAL RESULTS

Dissolved metal results for leachate water samples are presented in Volume 2, Appendix L. Average metal concentrations in leachate water samples are summarized in Table 4-4. Arsenic, copper, and zinc concentrations were consistently elevated compared to the starting deionized water used in the leachate testing experiments (LM-1).

The highest average arsenic concentrations were detected in TP-6 (353 ppm), TP-3 (29 ppm), and TP-1 (5.3 ppm). These water samples were passed through permeameters containing granular fill. Water passed through slag collected from TP-8 contained an average arsenic concentration of 0.061 ppm. Arsenic concentration distributions in leachate water and corresponding soil samples are presented on Figure 4-66.

The highest average copper concentrations were detected in TP-3 (63 ppm) and TP-6 (9.4 ppm). TP-3 and TP-6 were granular fill samples collected in the arsenic kitchen area. Slag (TP-8) leachate water contained an average copper concentration of 0.073 ppm. Copper concentration distributions in leachate water and corresponding soil samples are presented on Figure 4-67.

TP-3 (33 ppm) and TP-6 (5.4 ppm) granular fill samples also contained the highest average zinc concentrations. The average zinc concentration in leachate water collected from slag (TP-8) was 0.14 ppm. Zinc concentration distributions in leachate water and corresponding soil samples are presented on Figure 4-68.

# 4.6.6 COMPARISON OF LEACHING TEST RESULTS TO TOTAL AND EP TOXICITY RESULTS

As expected, granular fill and slag total metal results were much higher than EPTox and leachate testing results. The concentrated nitric acid extraction used in total metal analysis is a much stronger extraction medium than the pH-adjusted water used in the EPTox test procedure and column leachate testing analysis. See Figures 4-66 to 4-68 for total, EPTox, and leachate testing results for arsenic, copper, and zinc.

EPTox results were expected to be higher than leachate testing results due to the lowerpH water used in the EPTox test procedure. However, leachate testing metal concentrations for granular fill samples were generally higher than EPTox metal concentrations. This difference may be due to several factors:

- The granular fill to water ratio for EPTox analysis (1:20) was much lower than the leachate testing granular fill to water ratio (approximately 5:1). Higher granular fill to water ratios should result in an increase of metal concentrations in leachate water.
- The extraction time for EPTox analysis is 24 hours. In the leachate testing analysis, water is typically in contact with granular fill for approximately one week. Increased contact time with granular fill should result in higher metal concentrations in leachate water.

<del>1</del>3

Table 4-4. Summary of average metal concentrations in leachate water.

Test Pit No:TP-	1 TP-3 TP-6	TP-7 TP-8	LM-1			
Matrix:	Granular Fill	Granular Fill	Granular Fill	Granular Fill	Slag Fill Starti	ng Water
DISSOLVED METALS	S (in ppm)					
Antimony	0.715 ± 0.250	ND	ND	ND	<b>0.299</b> ± 0.189	ND
Arsenic	5.3 ± 8.4	28.7 ± 2.4	<b>352.9</b> ± 39.7	0.026 ± 0.017	$0.061 \pm 0.033$	0.006
Cadmium	0.001 ± 0	<b>0.825</b> ± 0.879	$0.068 \pm 0.043$	0.013 ± 0.007	$0.002 \pm 0.001$	0.003
Copper	$0.055 \pm 0.046$	62.6 ± 65.5	9.4 ± 5.8	0.013 ± 0.008	$0.073 \pm 0.066$	0.008
Lead	0.009 ± 0.009	<b>0.162</b> ± 0.128	ND	ND	$0.005 \pm 0.0001$	ND
Mercury	ND	ND	$0.015 \pm 0.015$	ND	ND	ND
Nickel	$0.253 \pm 0.209$	0.503 ± 0.241	$0.163 \pm 0.085$	$0.170 \pm 0.048$	$0.120 \pm 0.011$	ND
Selenium	$0.173 \pm 0.372$	<b>0.071</b> ± 0.068	ND	ND	ND	ND
Zinc	0.125 ± 0.154	33.1 ± 37.1	$5.4 \pm 3.4$	$0.189 \pm 0.205$	$0.140 \pm 0.145$	0.008

ND: Not Detected

<sup>\*</sup> Average concentrations plus or minus one standard deviation are presented except for sample LM-1. A total of five water samples were collected for each leachate test.

Granular fill samples with high EPTox metal concentrations generally also had high leachate testing metal concentrations. The highest EPTox and leachate testing arsenic and zinc concentrations were detected in granular fill samples collected in the arsenic kitchen area (TP-3 and TP-6). Granular fill collected from TP-3 also had the highest copper concentration for both the EPTox and leachate testing analyses.

Slag EPTox results were both higher and lower than leachate testing results. Slag EPTox results, which were lower than leachate testing results, may be due to the same factors discussed for granular fill samples. EPTox metal concentrations in slag samples may be higher than leachate testing metal concentrations due to the slag crushing done to prepare samples used in the EPTox test procedure. EPTox sample preparation techniques will be discussed further in Section 4.6.8's discussion of granular and slag fill leachability.

#### 4.6.7 FACTORS AFFECTING SLAG LEACHABILITY

The Bureau of Mines conducted a study to determine the leachability of copper reverberatory slag using the EPTox extraction procedure (Johnson et al. 1982). According to this study, the leachability of slag depends on several factors including particle size and surface area, silica content, slag cooling history, and oxidation state of slag metals. The leachability of arsenic, copper, lead, and zinc from slag was greatly affected by the slag particle size. Smaller size slag particles exhibiting large surface areas were shown to leach much higher levels of these metals than coarser particles.

According to a study conducted by Robbins et al. 1983, the leachability of trace metals from slag is limited by the silica content and chemical form of the metals. Higher silica contents in Asarco copper slag reduced the leachability of most metals.

Crecelius (1986) conducted laboratory experiments to study the release of trace metals to water from Asarco slag. Leaching tests were conducted using acidified fresh water (pH 5.0) and seawater (pH 8.0). Crecelius concluded that:

- Seawater and fresh water leach arsenic, silver, copper, and lead from fresh slag, but little or no cadmium, mercury, nickel, and zinc.
- The leaching rate decreases almost linearly within the first week after water comes into contact with fresh slag.
- Leaching rates of freshly granulated slag decrease markedly after three to four months of exposure to flowing seawater. The slag shows little toxicity to marine organisms.
- The Asarco slag fill is not a significant source of trace metal loadings to Commencement Bay.

Slag leachate metal concentrations reported in the studies conducted by Crecelius and Hart Crowser were much lower than leachate metal concentrations measured for granular fill samples.

Hart Crowser's slag leachate metal results were generally higher than the values reported by Crecelius. However, the leaching test procedures and conditions were significantly different between the two studies. Leachate testing conducted by Hart Crowser had much longer contact times between soil and water than the Crecelius study. In addition, the samples collected by Hart Crowser were composites of one pore volume of water. Crecelius collected discrete samples daily.

#### 4.6.8 LEACHABILITY OF GRANULAR FILL VERSUS SLAG FILL

As discussed in sections 4.4.3.1 and 4.4.3.2, slag samples generally contained much higher total metal concentrations than granular fill samples. Total arsenic, copper, and zinc average concentrations were 3 to 17 times higher in slag versus granular fill. However, granular fill samples had a higher average EPTox arsenic concentration and only slightly lower EPTox copper and zinc concentrations when compared to slag fill. In addition, slag EPTox results may be positively biased due to the crushing of slag samples during drilling and sampling activities. The leachability of slag and granular fill samples may vary significantly in areas affected by acid spills and in areas containing large volumes of woodwaste or other organic constituents.

Ratios of total versus EPTox metal concentrations were calculated for subsurface granular fill and slag fill samples collected from soil borings. These ratios reflect the degree of leachability for granular and slag fills under the conditions of the EPTox test. Higher ratios indicate a lower degree of metal leachability. The average ratios for selected metals are presented below:

	SLAG FILL Total/EP toxicity ratio	GRANULAR FILL Total/EP toxicity ratio
Arsenic	4,837	726
Cadmium	1,844	588
Copper	33,219	5,021
Lead	144,149	25,547
Mercury	20.9	14.2
Zinc	23,518	3,464

Average total versus EPTox ratios (excluding mercury) for slag fill are three to seven times higher than granular fill average ratios. This data provides further evidence that trace metals in a granular fill soil matrix are generally more leachable than in a slag matrix.

Leachate testing conducted as part of this work indicates that the concentration of dissolved arsenic, copper, and zinc in leachate water that passed through slag (TP-8) are several orders of magnitude less than water which passed through TP-3 and TP-6 granular fill samples. Water exposed to granular fill samples containing high EPTox metal concentrations generally exhibited high dissolved metal concentrations.

High EPTox concentrations in slag samples may not indicate high metal leachability to water as illustrated by the leachate testing copper results for slag in TP-8. Although slag in TP-8 had higher total and EPTox copper concentrations than granular fill in TP-6, the average dissolved copper concentration in TP-6 was over two orders of magnitude greater than TP-8 leachate water.

Slag EPTox results may be positively biased not only by the crushing of slag samples during sample collection but also during sample preparation for EPTox analysis. Any particles with a surface area less than 3.1 cm<sup>2</sup> or are too large to pass through a 9.5-mm sieve are crushed until these criteria are met. The slag crushing or analysis of only the finer slag particles in a given sample will probably result in higher EPTox concentrations than undisturbed slag samples. Leachate testing appears to be a more appropriate method to determine true slag leachability.

Although granular fill is more leachable than slag, the relative contribution of metals to groundwater depends also on the volume of slag and granular fill. The total volume of slag at the Asarco facility was estimated at 1,800,000 cubic yards compared to approximately 200,000 cubic yards of granular fill. The volume of slag fill is approximately eight times the volume of granular fill. More importantly, the volume of water saturated slag fill is approximately 22 times the saturated volume of granular fill. However, leachate testing results indicate that water flowing through granular fill samples can contain several orders of magnitude higher metal concentrations. Based on the leaching test results, granular fill at the Asarco site is likely the source of elevated trace metal concentrations in groundwater.

#### 4.7 MARINE SEDIMENT

#### 4.7.1 SURFICIAL SEDIMENT

The top 2 cm of marine sediments were sampled at 100 stations, and several stations were sampled more than once for a total of 125 surficial marine sediment samples. Ninety-one of the stations sampled were in the project area, and nine were reference stations.—A summary of the surficial sediment chemistry data is presented in Appendix F of this volume, and the data are presented in Volume 2, Appendix M.

#### 4.7.1.1 Metals

Results of marine surficial sediment sampling within the project area for metals are shown in Figures 4-69 through 4-73. Metal concentrations were generally highest near the slag pile that forms the breakwater for the yacht basin and in the nearshore areas off the copper dock and south dock. Metal concentration isopleths were very similar for

arsenic, copper, lead, and zinc, and concentrations above 3,000 ppm were reported for all four metals at nearshore areas off the slag pile, with values reaching 20,000 ppm for zinc. Mercury was found in high concentrations only at the nearshore stations near the docks on transects 10, 12, and 15. All metals show a trend of concentration highs at nearshore sampling stations and a sharp decrease in concentration proceeding toward offshore stations. Metal concentrations at the stations farthest offshore, toward the end of transects 9, 11, and 13, were very low, with most less than 30 ppm. Even transects 4 and 6, which had the highest nearshore metals concentrations, had quite low levels at the deepest stations on the same transects.

At some of the transects, particularly transects 3 and 4, metal concentrations did not decrease with distance offshore as dramatically as other transects. Two explanations are offered for this phenomenon. First, current studies near the smelter have shown that strong currents run from transect 20 toward transect 1 in a northwesterly direction (Parametrix 1984), and contaminants from the smelter reaching Commencement Bay would be carried primarily to the northwest toward Point Defiance. Second, the steepness of the bottom topography off the slag fill area would also contribute to deposition of contaminants contained in slag particles in this area. The reason for this is that slag eroding from the slag fill area would naturally move downslope and, in combination with current patterns, be deposited offshore from transects 7 through 3.

EPTox metals analysis results were surprisingly low given the high values for metals in many of the marine sediment samples. Table 4-5 shows that for the 28 stations sampled for EPTox analysis (all of the 1988 surficial chemistry stations), only 10 stations had detectable limits of the metals of interest. Station T4-2 produced detectable arsenic at a very low level, and nine other stations produced very low levels of lead. No copper, mercury, or zinc were recorded from any of the samples.

Table 4-5. Detected EPTox metals.

Station No.	As (ppm)	Pb (ppm)	Cd (ppm)
T3-5		0.020	
T4-2	0.830		0.000
T4-4 T5-0		0.022	0.003
T6-1		0.033 0.020	
T8-4		0.020	·
T10-1		0.100	
T10-2		0.067	
T12-1		0.520	0.025
T16-1		0.020	
T22-1			0.003
T22-2		0.020	0.005

# 4.7.1.2 Organics

The results of the analyses for organic pollutants are summarized on Table 4-6. Of the 91 project area stations sampled, 11 stations had detectable concentrations of LPAHs (low molecular weight polynuclear hydrocarbons) and 15 had detectable concentrations of HPAHs (high molecular weight polynuclear hydrocarbons). No station had concentrations of PCBs or dibenzofuran above detection limits, except T12-1 with 1900 ppb dibenzofuran in 1988. Data from this study often show considerably lower, or even nondetectable, values of LPAHs and HPAHs compared to values from previous study at similar sampling locations (Tetra Tech 1985).

Table 4-6. All stations where organic pollutants were above detection limits.

Station Number	LPAH (ppb)	HPAH (ppb)
T2-2 <sup>1</sup>		1,000
T4-0 <sup>1</sup>	2,430	12,150
$T5-0^2$	_,	16,000
T9-1 <sup>†</sup>	880	7,250
T10-0 <sup>1</sup>	4,010	12,320
T10-1 <sup>1</sup>	,	3,770
T10-1 <sup>2</sup>	1,870	11,650
T10-2 <sup>2</sup>	2,480	2,570
T11-1 <sup>1</sup>	,	560
T12-1 <sup>1</sup>	2,310	17,280
T12-1 <sup>2</sup>	53,410	86,180
T13-1 <sup>1</sup>	460	7,770
T14-1 <sup>1</sup>	610	1,420
$T16-4^2$	2,600	2,990
T17-1 <sup>1</sup>	4,600	18,800
T18-1 <sup>1</sup>	3,110	14,800
T19-1 <sup>1</sup>	·	1,030
$T21-1^{1,3}$	1,870	9,890
T22-1 <sup>1,3</sup>		1,710
T22-2 <sup>1,3</sup>		2,300

<sup>&</sup>lt;sup>1</sup>1987 Sampling

<sup>&</sup>lt;sup>2</sup>1988 Sampling

<sup>&</sup>lt;sup>3</sup>Reference Station

Highest levels of LPAH and HPAH are confined to the nearshore areas very close to the smelter and to the southeast, or "upcurrent" of the site. The results indicate organic pollutants are not being dispersed very far from the site. All of the stations, with the exception of T16-4, where organics were detected were nearshore stations.

#### 4.7.1.3 Radium

Results of radium sampling are shown in Figure 4-74. Radium samples were collected at only nine locations and not at all marine surface sediment sampling stations. Radium was detected at six of the nine sampling locations. A maximum concentration of 3.61 pCi/g was found at station T6-1. Radium concentrations ranged from 0.23 to 1.6 pCi/g at the remaining five stations where radium was detected.

# 4.7.1.4 Slag Particle Separation

Marine surficial sediments from four stations were dried and sorted into three specific size fractions, and each of these fractions was compared to a homogenous sample of the same sediments that had been analyzed directly from the field. Another sample from the same grab was dried, fractioned, and recombined to be used as a control. The results of the slag particle separation experiments are summarized in Figures 4-75 through 4-79.

In general metal concentrations were relatively high at stations T4-1, T4-2, and T15-1 and fairly low at station T14-2. Theoretically, the values for the field and combined samples should be similar, and this was true for all metals analyzed, except lead in general and mercury at station T15-1 (Figures 4-77 and 4-78). The combined samples were used as a control to see if laboratory procedures might affect chemical analyses.

It was hypothesized that, perhaps, a greater portion of the metals would be contained in the larger fractions that contained most of the slag. This did appear true for lead and zinc (Figures 4-77 and 4-79). However, for mercury the opposite seemed true with the greatest concentrations appearing in the smallest fractions (Figure 4-78). The results of the analyses for arsenic and copper were very inconclusive with the higher concentrations occurring in the larger fractions at the stations northwest of the Asarco plant and in the smaller fractions at the stations southwest of the plant (Figures 4-75 and 4-76).

#### 4.7.2 SEDIMENT CORES

The top 1.5 m of marine sediments were core sampled at six nearshore stations near the Asarco Tacoma Smelter (Figure 2-12). The upper 0.5 m of sediment at each station was sampled in increments of 0.1 m, and one or more samples were collected from greater depths for a total of 39 samples.

#### 4.7.2.1 Metals

The results of marine sediment core analyses for metals are tabulated in Volume 2, Appendix N. Concentrations of total arsenic, total lead, and total zinc were highest near the slag pile that forms the breakwater for the yacht basin and in the nearshore area of the copper dock. High levels of these metals were also detected near the southeast end of the slag fill area at Station T16-0. Zinc concentrations exceeded 10,000 ppm at Stations T7-2 and T16-0 where the core samples consisted of black sand-sized slag particles. As expected, copper concentrations were highest (>10,000 ppm) at Station T10A-1 near the copper dock. The areal distribution of metals contamination in the top 1 dm of core samples was generally consistent with the distribution of metals in surficial sediment grab samples.

Marine sediment core samples generally exhibited a sharp drop in total metals concentrations below the upper 0.3 or 0.4 m, particularly at the stations where metals contamination was greatest (Figures 4-80 through 4-83). The exception was at station T7-2 where high levels of total metals extended beneath the 0.5 m sediment depth. The T7-2 core was described as uniformly black sand-sized slag particles to a depth of 0.9 m; hence total metals concentrations were expected to remain consistently high to this depth. The patterns of decreasing total metals concentrations with increasing sediment depth were very similar among the four metals tested at each station. Results of sediment core samples reported in the Commencement Bay Nearshore/Tideflats Feasibility Study (Tetra Tech 1989) also exhibited a sharp drop in metals concentrations beneath the top few decimeters of sediment offshore from the Asarco Tacoma Smelter.

EPTox metals concentrations were relatively low in all marine sediment core samples indicating only a small fraction of the total metals present are leachable in a weakly acidic environment (Volume 2, Appendix N). EPTox chromium, selenium and barium were not detected in any samples. EPTox mercury and silver were each detected in only one sample, and they were only slightly higher than detection limits. Low levels of extractable cadmium (≤0.025 ppm) were detected in about 20 percent of the core samples, principally in samples from Station T10A-1. EPTox copper was detected in about one-third of all samples at 0.021 to 0.64 ppm. Extractable lead and arsenic were detected in nearly all samples, but concentrations did not exceed 0.063 ppm. EPTox zinc was detected in all samples at concentrations ranging from 0.017 ppm to 6.0 ppm.

A trend toward decreased EPTox metals concentrations with increased sediment depth was exhibited in most core samples, but the drops in concentrations were not as sharp and consistent as with total metals. The reason for the weaker trends was that extractable metals concentrations were low throughout the sediment cores. High total metals concentrations in the upper few decimeters of sediment did not have correspondingly high EPTox metals concentrations.

Although total metals results and EPTox metals results are expressed in different units, the ratios between these data provide an indication of the relative leachability of metals in different sediment samples. Generally, the EPTox: total ratios for arsenic, copper, lead, and zinc were lowest where the total metals concentrations were highest. The

ratios of EPTox arsenic: total arsenic ranged from 1:93,817 to 1:311,250 where total arsenic exceeded 5000 ppm in the upper 0.5 m of sediment at Station T7-2. These ratios ranged from 1:72 to 1:1529 where total arsenic concentrations were less than 50 ppm. EPTox: total concentration ratios were also lowest for copper, lead and zinc in the upper 0.5 m of sediment at Station T7-2 and highest where total concentrations were low. The ratios of EPTox metals to total metals suggest that although total metals concentrations are high in the slag sand at Station T7-2 and other nearshore areas, the leachable amounts available to ecological pathways are very low throughout the area sampled. The proportions of EPTox metals and total metals are illustrated in Figures 4-84 and 4-85.

## 4.7.2.2 Organics

The results of organic pollutant analyses are tabulated in Volume 2, Appendix N. Table 4-7 summarizes these results for marine sediment core samples where organic contaminants exceeded detection limits. The analytical laboratory had to dilute several samples due to matrix interference, thus the detection limits for these samples were increased by up to a factor of 100 (see Volume 3). No organic pollutants were detected at Station T13-2.5 (Figure 2-12). PAHs were detected only in the upper decimeter of sediment at Stations T7-2 and T10-1 and were not detected in sediments at Stations T2-1 and T13-2.5. The highest concentrations of LPAH and HPAH occurred in sediment cores collected close to shore (Stations T10A-1 and T16-0) as in the surficial sediment grab samples. These concentrations were 36,000 ppb in the uppermost decimeter of sediment at Station T16-0.

Organic pollutant levels decreased with increasing sediment depth to less than detection limits below 0.5 m at all stations sampled. The sharp drop in LPAH in the upper few decimeters was consistent with the trend exhibited by core sample results reported in the Commencement Bay Nearshore/Tideflats Feasibility Study (Tetra Tech 1989).

#### 4.7.3 BIOLOGICAL INVESTIGATIONS

#### 4.7.3.1 Benthos

#### Introduction

Analysis of the benthic marine samples yielded a substantial data set that can be used to describe in detail the changes in the marine fauna near the Asarco facility. Sediment was collected at 12 stations. Two of these stations (T22-1 and T22-2) were distant from the rest and used as comparative reference stations. The remaining 10 stations were arrayed from north (T2-5) to south (T16-4) along the facility and at varying distances from the shoreline. This arrangement results in a data set affected by several variables that impact organism distributions. These variables include water depth, native sediment particle-size distribution, proximity to sources of contamination, and slag particle-size distribution. Other variables act upon benthic animals in some direct way. These

Table 4-7. All sediment core samples where organic pollutants were above detection limits.

				<u>Organic</u>	: Pollutant (ppb)					
Sediment Depth (m)	T10A-1		¥16-0		17-2		T2-1		Т10-1	
0.0 to 0.1	anthracene phenanthrene  LPAH  pyrene benzo(a)anthracene benzo(a)pyrene chrysene  HPAH  bis(2-ethylhexyl) phthalate	870 4070 4940 3550 1740 1370 2240 8900	LPAH fluoranthene	36,000 36,000 <u>36,000</u> 36,000	naphthalene 2-methylnaphthalene LPAH benzoic acid	660 590 1250 3500	4-methylphenol	510	benzoic-	540 1000 1540 3100
0.1 to 0.2	LPAH  pyrene benzo(a)anthracene benzo(b)fluoranthene chrysene  HPAH 1	1500 2900 4400 4900 1500 2700 2500	phenanthrene  LPAH  benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthen benzo(g,h,i)perylen chrysene fluoranthene pyrene	1830 3150 3540						
	bis(2-ethylhexyl) phthalate butyl benzyl phthalate	7200 2500	НРАН	12,950						

Table 4-7. All sediment core samples where organic pollutants were above detection limits (continued).

Organic Pollutant (ppb)									
Sediment Pepth (m)	T10A-1		T16-0		17-2		12-1		710-1
).2 to 0.3	benzo(b)fluoranthene chrysene pyrene	6300 5300 7600	phenanthrene LPAH	<u>2860</u> 2860		:			
	HPAH 1	19,200	benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthen benzo(g,h,i)perylen chrysene fluoranthene pyrene						
			НРАН	10,280					
.3 to 0.4	phenanthrene 2-methylnaphthalene	1250 4200							
	LPAH	5450							
	benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene chrysene ideno(1,2,3-cd)pyrer pyrene	990							
	НРАН	9160							
.4 to 0.5	•						is(2-ethylhexyl) hthalate	480	

variables include salinity, light intensity, benthic topography, and current intensity. Thus the benthos sampled is a result of many physical and chemical variables that the organisms act upon in their choice of habitat.

The effects of toxic contamination of the marine benthic sediments was expected to be clearly noticeable in the examination of the benthic animals living on and in these sediments. Sampling at the 12 stations provided 59 replicates for sorting, enumeration, and identification. Station T2-5 was in an area where the substrate was solidly packed; only four replicates were collected there. Five replicates were obtained from all other stations. Examination of all these samples provided over 32,000 specimens from 440 taxa for more detailed analysis.

In general, the term "taxon" rather than "species" will be used here to distinguish various benthic organism groups. Although many of the organisms could be successfully assigned to species, many numerically important organisms could not be placed in that precise taxonomic level. The lack of precision was due to two factors: (1) many organisms were juveniles that lacked adult characteristics and (2) many organisms were living within the larger sediment particles. Of the organisms that lacked adult characteristics, most were from the sea cucumber and crab groups. Polychaete annelids and some smaller crustacea were most abundantly found in tubes inside the relatively porous slag particles. These slag particles had to be crushed with mortar and pestle in the laboratory to allow removal of the organisms. This mechanical abrasion sometimes damaged the animals so that precise identification to species was not possible.

## Qualitative Station Diversity

The samples varied substantially in the mean number of organisms collected, from a low of 912 organisms/m<sup>2</sup> at station T11-7 to a high of 22,682 organisms/m<sup>2</sup> at station T22-1 (Figure 4-86a). Within each of these stations the relative proportions of the major taxa also varied. For example, annelids dominate station T12-1, but are proportionally about one half as abundant at station T6-3. All of the major taxa show similar shifts (Figure 4-86b).

Similarly, the wet-weight biomass collected at each station varied over a factor of about 8 (Figure 4-87a). Station T12-1, which had one of the highest counts of organisms, had the smallest biomass, at  $13.6 \text{ g/m}^2$ . Station T4-2 had the highest biomass with about  $117.7 \text{ g/m}^2$ . The relative taxonomic proportions of this biomass also varied radically between the sites (Figure 4-87b).

These data indicate the stations did not sample a single community or assemblage of organisms. The differences between the station results, even on a gross level, indicate several different assemblages. This interpretation is supported by a quantitative examination of the cluster analysis based on the Bray-Curtis dissimilarity coefficients computed on a station by station basis (Figure 4-88). This analysis groups those stations with their "nearest neighbor" determined by the proportional abundance of organisms in the samples. All replicates were pooled for this component of the analysis to obtain the

largest data set, and the data were transformed to minimize the effects of very abundant taxa.

A few of the results of the cluster analysis were predictable. For example, Stations T22-1 and T22-2 are relatively similar to one another. Stations T12-1 and T10-1, which were presumed to be the most contaminated, were somewhat similar to one another, yet they were different from the other stations. What was not predicted was that none of the other stations were particularly similar to, and some even unlike, any other of the stations sampled (Figure 4-88).

This overall diversity of the benthos data is reflected in a close examination of the array of species collected from each station (see end of Chapter 4, Table 4-8). Several of the stations have a substantial diversity of organisms. This is particularly noticeable in the data from stations T4-2, T6-3, T8-4 and T22-1; all have an excess of 190 taxa. Only stations T11-7 and T12-1 had less than 100 taxa collected in their samples. Station T12-1, containing the smallest number of taxa, still had 76 species collected in the samples from that site.

Dominance of the species list by very few common taxa is a typical situation in polluted marine environments. To assess this phenomenon, Table 4-8 lists the species found at each station in decreasing order of abundance. These species lists are truncated at 90 percent. Thus the most common species is listed first, then the next most common and so on until 90 percent of the organisms collected are enumerated. Station T12-1 showed a distribution of organisms typical of a polluted environment. Although 76 taxa were recorded from that site, 83 percent of the animals collected were of one polychaete annelid species, Notomastus tenuis, and only three other species were necessary to comprise 90 percent.

Those data should be contrasted with the data obtained from the nearby stations T4-2, T6-3, and T8-4. There 51, 81, and 80 taxa were needed to comprise 90 percent of the organisms collected at the respective sites. In the case of these three stations, and at most of the other stations, there is no domination of the community by one or a few species.

#### Quantitative Station Diversity

The qualitative indication of diversity and the lack of dominance by one taxon is reflected by the more quantitative diversity measures, the Shannon-Wiener Index (H'), and Simpson's Index (C). The Shannon-Wiener Index ranges upward from 0 and measures the amount of information that can be obtained from one individual in the sample. Generally it is considered that values of H' from between 0 to about 2 represent sparse assemblages under some stress, while values in excess of 3 are likely to be found in diverse communities containing enough diversity for normal ecological interactions (Poole 1974). The samples from station T12-1 gave an H' of 1.388, indicating a substantially disturbed assemblage. Station T11-7 was the only other station with a H' value that was less than 3.

Simpson's Index measures diversity in another way. This index measures the degree of dominance of one species in the sample, and can range from zero to one. Low values, below 0.200, of this index represent an even distribution of the taxa with little domination of the assemblage by a few taxa. If the values of Simpson's Index exceed 0.500, the community is dominated by very few taxa (Poole 1974). In these samples, the only station whose Simpson's Index value exceeded 0.200 was station T12-1, with C = 0.523.

The final quantitative measure used to describe diversity in the benthos from these stations was a measure of "evenness = J." The evenness index ranges from 0 to 1 and examines diversity as a relative measure of the maximum possible diversity. The closer the value of J is to zero, the closer the total domination by one species. Generally, if the evenness of the sample exceeds 0.6, the sample is not regarded as being dominated by a single or small group of taxa. Station T12-1, with J = 0.320, is the only one of these stations with an evenness value less than 0.6.

#### Organism Assemblages and Presumed Interactions

The number and types of each individual taxon collected and the interactions between them provide an additional series of indications of the well being of the benthic community. Many of the ecologically important organisms for each station are listed in Table 4-8 (end of Chapter 4). It is likely that some of the more important, but rarer predatory animals were not sampled. These larger animals, such as the sea stars <u>Pisaster brevispinus</u> and <u>Luidia foliolata</u> or the moon snail <u>Polinices lewisii</u>, are normally found with population densities of less than one animal per 10 m<sup>2</sup>. It would be unlikely that they would be sampled. However, their presence may be inferred by the presence of their prey, direct evidence of their predation, or their juveniles.

The entire array of organisms found in an area is important in determining whether or not that area is contaminated and perturbed to a major extent. In Puget Sound waters, many of the benthic marine communities are structured by the actions of their major predators. Most of these benthic predators are either sea stars or snails, and they appear particularly sensitive to pollutants. Metals, for example, are important molluscicides, and snails would be expected to respond strongly to metallic contamination. Areas subject to contamination would then be expected to have few complex predatory interactions, and simple food chains with few levels would be the rule.

Similarly, the presence of many larval, juvenile, or reproductive forms of each taxon could give evidence of the "health" of the benthic community. Examination and assessment of larval abundance will assist in determining if the assemblage is capable of maintaining itself by normal regular recruitment, or if it depends upon adult immigration or haphazard, spotty recruitment of larvae into the area.

#### Reproduction and Larval Recruitment

These samples were taken in the early summer, when most Puget Sound marine invertebrates spawn, develop into larvae, and then settle and metamorphose into juveniles

in their adult final habitat. Most invertebrate larvae actively choose where they will settle and change into juveniles. This is the most important choice these animals make, and it is not a passive process. If the habitat does not give sufficient or the wrong sensory cues, then settlement will not occur. Larvae are also generally much more sensitive than adults to various types of contamination and toxic agents.

Larvae or recently settled juveniles were collected at a number of the stations (Table 4-9). Two of the four major taxonomic groupings, arthropods and miscellaneous taxa, were represented by populations containing juvenile animals. Arthropod, sea cucumber (holothuroid), and sea star (asteroid) recruitment were both relatively high in several of the stations. Stations T4-2, T22-1, and T22-2 all had substantial recruitment of these major taxa. Fewer juveniles were collected at the other stations, but were absent only at station T12-1. Although a few juveniles arthropods or sea cucumbers were found at stations T10-1 and T11-7, they were uncommon.

Specific enumeration of juvenile, larval, or immature forms was not routine in either the sorting or taxonomic analysis. It simply was not anticipated that juveniles would be common enough to make the analysis of recruitment worthwhile. Some arthropod and echinoderm larvae and immature forms were consistently counted.

Sea stars are often the most important predators in marine ecosystems and are also particularly common in Puget Sound ecosystems (Paine 1966; Mauzey et al 1968; Birkeland 1974). Adult sea stars are often found in densities ranging from one animal per 10 m<sup>2</sup> to one per 1,000 m<sup>2</sup>. Due to the small area sampled, it is unlikely that any adult sea stars would be collected. However, if conditions are suitable, juvenile sea stars may be abundant in early summer. That appears to have been the case at some of the stations sampled.

The asteroid (sea star) larvae collected belonged to the families Goniasteridae and Solasteridae. The most likely species represented by the goniasteridae is Mediaster aequalis, a relatively generalized predator. In the lower Puget Sound region this star is likely preying upon bryozoans or various cnidarians. These taxa are well represented where goniasterid juveniles were collected. The latter sea star family might be any one of several species of Solaster or the rosy sun star, Crossaster papposus. Solaster species predominantly prey on sea cucumbers. Juvenile sea cucumbers were common at those stations where small solasterids were found. Thus these asteroids might be recruiting into the area because of the prevalence of small prey for the small asteroids to eat.

Additionally, asteroids in these groups often settle from the plankton in response to tubes secreted by chaetopterid polychaetes (Strathmann 1987). Chaetopterids are also commonly found in the areas where the small asteroids are common. Thus, the recruitment effect of potential larval food cannot be separated from the effect of polychaete tubes. The presence of recuits indicated normal larval settlement and metamorphosis in this important group of predators.

Table 4-9. Immature forms collected at all Asarco benthic stations.

# NUMBERS PER SQUARE METER FOR EACH STATION :MEAN+/-1 S.D.

# **STATIONS**

	T2-5	T3-5	T4-2	T6-3
Cancer sp. Lophopanopeus sp. Pinnotheridae sp.		2.0±4.0	22.0±7.5 16.0±18.5 44.0±36.1	10.0 ± 11.0 2.0 ± 4.0 18.0 ± 13.3
ARTHROPODS TOTAL		$2.0 \pm 4.0$	82.0 ± 62.1	30.0±28.2
Goniasteridae sp. Solasteridae sp.	$2.5 \pm 4.3$ $5.0 \pm 5.0$	20.0 ± 17.9	12.0 ± 11.7	10.0±8.9
ASTEROIDS TOTAL	$7.5 \pm 9.3$	$20.0 \pm 17.9$	$12.0 \pm 11.7$	$10.0 \pm 8.9$
Holothuroidea sp. Phyllophoridae sp Cucumaria sp. 2 Cucumaria sp. Eupentacta sp.	7.5 ± 8.3	2.0±4.0 2.0±4.0 12.0±7.5	12.0±11.7 96.0±90.0	2.0 ± 4.0
Pentamera sp. Leptosynapta sp.		$10.0 \pm 12.6$	2.0±4.0	
HOLOTH. TOTAL	$7.5 \pm 8.3$	26.0±28.1	110.0 ± 105.7	$2.0 \pm 4.0$
MISCELLANEOUS (Mogulidae sp.)				4.0±4.9
NO.PER SQ. M.	15.0 ± 17.6	48.0±50.0	204 ± 180	46.0 ± 46.1
Callianassa sp. Cancer sp. Lophopanopeus sp.	8.0±9.8 2.0±4.0 14.0±15.0	6.0	4.0±4.9	
Pinnotheridae sp.		6.0		
ARTHROPODS TOTAL	$24 \pm 28.8$	6±0	$4.0 \pm 4.9$	

Table 4-9. Immature forms collected at all Asarco benthic stations (continued).

# NUMBERS PER SQUARE METER FOR EACH STATION :MEAN+/-1 S.D.

# **STATIONS**

	T2-5	T3-5	T4-2	T6-3
Holothuroidea sp. Phyllophoridae sp Cucumaria sp. 2 Eupentacta sp. Pentamera sp.	2.0±4.0 4.0±4.9 2.0±4.0 2.0±4.0 2.0±4.0			
HOLOTH. TOTAL	$12.0 \pm 20.9$			
NO.PER SQ. M.	$36.0 \pm 49.7$	$6.0\pm0.0$	$4.0 \pm 4.9$	NONE
Synidotea sp. Callianassa sp. Brachyura sp. Cancer sp. Lophopanopeus sp. Pinnotheridae sp.	$2.0 \pm 4.0$ $22.0 \pm 17.2$ $2.0 \pm 4.0$	4.0±8.0 2.0±4.0	2.0±4.0 90.0±36.9 82.0±38.2	26.0±10.2 4.0±4.9
ARTHROPODS TOTAL	24.0±21.2	$6.0 \pm 12.0$	174.0±79.1	32.0 ± 19.1
Goniasteridae sp.				$14.0 \pm 8.0$
ASTEROIDS TOTAL				14.0 ± 8.0
Holothuroidea sp. Phyllophoridae sp. Cucumaria sp. 2 Cucumaria sp. Pentamera sp. Leptosynapta sp.	2.0±4.0	4.0±4.9 48.0±26.4 10.0±6.3	$6.0 \pm 8.0$	$24.0 \pm 28.7$ $10.0 \pm 20.0$ $12.0 \pm 19.4$ $48.0 \pm 27.9$ $16.0 \pm 13.6$
HOLOTH. TOTAL	2.0±4.0	62.0±37.6	6.0±8.0	110.0±109.5
NO.PER SQ. M.	26.0±25.2	68.0±49.6	180.0±87.1	156.0 ± 136.6

Because sea stars and sea cucumbers often do not acquire all of their definitive characters until a few weeks or months after settlement, taxonomists often note these small animals as juveniles. Juveniles of the other major taxonomic groupings were not observed in the samples. Small mollusks and annelids were commonly collected but not specifically noted as juvenile animals. Even as juveniles, these taxa are likely to be relatively identifiable, thus taxonomists identified them without any special notation as to age. Additionally they have continuous growth, without distinct early life-history stages.

Recently metamorphosed arthropods with defined juvenile characteristics were also noted. Small individuals of both of these major taxa are likely to be identifiable as juveniles of a given genus or family long before they acquire the adult characteristics necessary to identify them to species. Consequently, it is relatively easy to assess recruitment in these two major taxa. It is difficult to do this for the other taxa, and to this extent our data were biased. Given the population sizes and the species diversities at all sites, recruitment of a substantial number of annelids and mollusks occurred regularly.

The presence of juveniles indicated suitable conditions for these small, sensitive, animals. Conversely, the absence of the juveniles likely results from inappropriate substrate type or quality, presence of potentially toxic materials, lack of suitable prey, or any of a number of other conditions. Thus while the presence of juveniles denotes suitability of the habitat, and absence denotes unsuitability, the absence of juveniles cannot determine why the habitat is unsuitable.

In addition to larval recruitment from distant populations, some of the animals at stations T3-5, T6-3, T8-4, and T16-1 were reproductively active during or before sampling. Eggs or capsules containing eggs were found in the samples from those stations, sometimes in relatively great numbers (Table 4-10). Most of these eggs or egg capsules were from gastropod mollusks. No attempt, however, was made to directly assess reproductive condition for any of the sampled animals.

Table 4-10. Number of Unidentified Eggs Collected in Benthic Samples.

Number/Square Meter ± 1 Standard Deviation							
Station	T2-5	T3-5	T4-2	T6-3	T8-4	T10-1	
Number	0	18±24	0	4±8	10±20	0	
Station	T11-7	T12-1	T16-1	T16-4	T22-1	T22-2	
Number	0	0	132±23	0	0	0	

#### **Ecological Interactions**

Many of our samples, particularly those from the areas containing substantial coarse sediment showed evidence of diverse ecological interactions, including fully developed food chains and larval recruitment. For example, Station T4-2, had a mean of 48 individuals of relatively large Eupentacta pseudoquinquesemita per m<sup>2</sup>. About twice that number of juvenile Eupentacta of undetermined species were collected at the same time. These were likely the recently settled juveniles of that same species. Thus the sea cucumber Eupentacta pseudoquinquesemita, which lives between, under, and on coarse sediment, had a stable population in the area. Although they are much less abundant than their prey, sea cucumber predators were common in the same area. The gastropod Balcis, which eats sea cucumbers, was found in densities of 8 m<sup>2</sup> at the same station (Volume 2, Appendix F).

Olivella baetica were commonly found at station T2-5 and infrequently elsewhere. Cylichnella species were found scattered throughout the site. They are both gastropods that prey on foraminiferans. Foraminiferans are shelled protozoans that live within the sediment, eating sediment bacteria. Gastropods are notoriously sensitive to metal contamination; most snail poisons are copper based. These two species live within the sediment, and ingest it while eating their prey. They were found at Stations T2-5, T4-2, T8-4, T11-7, T12-1, and T22-1, indicating that at these stations, the sediment is not toxic.

Predators and their prey were collected at every station. Normal predator-prey relationships can be inferred in some degree at each station. Because mollusks are particularly sensitive to metal toxicity, interactions involving small shell-less gastropods, or nudibranchs, are particularly important. One major group of nudibranchs, the aeolidacea, eat hydroids. This group was commonly collected (Volume 2). Another relatively abundant group of nudibranch species, the doridacea, have species that commonly prey upon sponges.

# 4.7.3.2 Bioassays

#### Oyster

The oyster bioassay procedure allows the examination of two effects of any potential toxicant on the organisms: (1) the relative amount of survival and (2) the relative amount of abnormality among survivors. Only swimming survivors are assessed for normality.

Because of the large number of samples tested, the assays were completed in two separate experiments. The first experiment was started on July 16, 1988. The second on August 11, 1988. One sea water control and one clean sediment treatment was done with each batch. The mean survival in the clean sediment was  $78.0 \pm 39.1$  percent and  $92.0 \pm 13.5$  percent, respectively. The corresponding survival in the sea water controls was  $95.4 \pm 1.6$  and  $98.3 \pm 2.2$  percent. Oyster bioassay test data are provided in Volume 2, Appendix O.

Figures 4-89 and 4-90 depict the primary results from the oyster bioassay. In general, the most noticeable pattern is substantial mortality or abnormality noticed in treatments using sediments from the bioassay stations nearest the shore. Virtually all the samples showed some reduction in either amphipod survival, oyster survival, or oyster rate of abnormality. There was substantial variance in most of the treatment containers. Such variation contrasted to the low variability observed in the sea water controls.

Of particular interest are the results from the sediments from Stations T0-2, T0-3, T22-1, and T22-2. These stations were substantially distant from the rest of the stations. The sediment from the "T0" transect was collected north of the rest of the samples; sediment from the "T22" transect was collected several kilometers to the south. These sites were treated as "control" sediments, assuming they would be little different from the clean sediment (CS) controls in the bioassays. The clean sediment used in the CS treatments came from the beach at Whidbey island, where the amphipods were collected.

The distant Commencement Bay sites give the same results in the bioassays as did most of the stations nearer the Asarco site. In most cases, they also showed no significant differences from the control sediments. The stations that differed from all others, showed effects of increased mortality in both the oyster and amphipod tests, and showed increased abnormality in the oyster larval tests were stations T3-5, T4-2, T5-0, T6-1, T10-1, T12-1, T16-1, and T16-4. While some sites, particularly station T6-1, showed similar results with both bioassays, some showed contradictory results between the amphipod and oyster tests.

The pattern of low survival in all the treatments involving sediment compared to the sea water controls (Figure 4-89) indicates a general sediment effect. This effect is substantial. With this pattern of low survival, no significant effect due exclusively to contamination can be discerned except in the extreme cases.

In the oyster tests, several sites (T2-5, T3-2, T3-6, T8-4, and T22-1) had substantially lower percentages of abnormal embryos (Figure 4-90). Most of the others differed insignificantly from one another and the distant Commencement Bay sites. The noticeable exceptions were station 10-1, where most of the embryos were abnormal, and station 6-1, where none of the embryos survived.

#### Amphipod Bioassays

The amphipod bioassay tests the relatively long-term survival of the test animals when they are forced to remain within the treatment sediment for 10 days. The treatments were examined daily for swimming, dead, or moribund individuals, and these data were recorded. The amphipod bioassays were also split into two test periods: the first began on July 22, 1988 and ran until August 1; the second began on August 5 and ran until August 15, 1988.

The results of the amphipod bioassay are depicted in Figure 4-91. Virtually all of the animals survived in the control treatments, indicating the validity of bioassay. Although in most cases the mortality was not substantial, mean survival in all of the treatments was depressed compared to the control. Survivability was particularly low in treatments involving sediment from stations T3-5, T4-2, T6-1 and T12-1. Sediment from all of these sites resulted in mean survival rates of 60 percent or less. Survival was particularly low in sediments from the nearshore sites, T6-1 and T12-1.

As in the oyster larval bioassays, the distant Commencement Bay sites (from stations T0-1 and T0-2 to the north, and T22-1 and T22-2 to the south) showed treatment effects similar to those from most of the nearby sites. In fact, with the exception of the stations mentioned above, none of the sampled sediment had any more deleterious effect on the amphipods than one of the distant stations, T0-3 (Figure 4-91). Mean amphipod survival was better in the sediment from stations T1-1, T2-1, T3-6, T11-7, and T16-1 than from any of the distant, supposedly uncontaminated, sediments.

Although some other patterns can be discerned in the results from the amphipod bioassays, they are, in general, statistically insignificant. Given the variability in the sediment treatments from the distant Commencement Bay sites, the only clear pattern that occurs is a depression in amphipod survivability in sediments from those areas with more slag. This indicates that amphipods, in particular, and crustacea, in general, should not survive well in slag-dominated sediment. This was not borne out in the examination of benthic community found at those sites. Sediments from station T4-2 caused substantial mortality of the animals in the amphipod bioassays, yet the amphipods, Ampelisca lobata, Ampelisca agassizi, Tritella pilimana, and Byblis cf. millsi had a mean aggregate population density at that station of 1050 animals per square meter. They amounted to 10.65 percent of the individual organisms found at that station. Furthermore samples from that station contained 9860 specimens from 192 taxa (Table 4-8c).

The only other station showing substantial depression in the amphipod bioassay survival rates where corresponding benthic data are available is station T12-1. Oyster bioassay data from this site also indicated substantial effects from this station. The benthic data were in agreement with these results. The number of taxa collected from this site was the smallest of any of the benthic sites examined. Although this reduced species assemblage was dominated by a few very abundant taxa, one of the dominant taxa, Tiron biocellata, was an amphipod.

There was a general tendency for sediments from areas immediately adjacent to the Asarco facility to depress amphipod survivability, oyster survivability, or normal oyster development. However, only the sediment from stations T6-1 and T12-1 had major effects in all three categories. There was good positive correlation between the bioassays with regard to oyster normality (or conversely, the relative lack of abnormal embryos), oyster survivability, and amphipod survivability (Table 4-11). Thus, the pattern of relative effects in both oysters and amphipods (Table 4-11) through all of the sediments was relatively similar.

Table 4-11. Correlation of bioassay results, mean value for all stations.

	Oyster Abnormality	Oyster Normality	Oyster Survival	Amphipod Survival
Oyster Abnormality		-0.5342 (25) 0.0059	-0.3437 (25) 0.0926	0.1375 (25) 0.5122
Oyster Normality	<0.001		0.6674 (25) 0.0003	0.5820 (25) 0.0023
Oyster Survival	NS	< 0.001		0.3562 (25) 0.0805
Amphipod Survival	NS	<0.01	NS	

NS> = Not significant at alpha level of 0.05 Other levels of significance indicated

CELLS: Correlation coefficient

(Sample size) Probability A general point should be made on how these bioassays demonstrate the biological effects of the particular toxic contaminants tested for here. Both the oyster larvae and amphipod bioassays conducted for this study used sediments from the various stations of the site. These sediments ranged from poorly sorted sediments with a wide range of particle sizes (for example, stations on transects T0, and T2) to those with a preponderance of very fine sediments, such as those stations from those stations on the southern-most transect, T22. No true sediment control was called for in the test protocols. Consequently, there was no way to differentiate purely physical sediment effects from the effects due to contamination. Unless the contaminant effects were extreme, they become lost in the effects due to these simply physical effects.

Neither of the tested bioassay organisms was normally found in close proximity to either of these physical sediment types. Since organisms are adapted to live in the habitat in which they are found, organisms such as <u>Rhepoxynius abronius</u>, which are characteristically found in well-sorted sand, are unlikely to survive well in sediments with a wide-ranging or inappropriately-sized sediment particle distributions. Even if this organism has been shown to be sensitive to contaminants, its utility as a sediment bioassay organism in totally unsuitable sediments must be questioned, particularly as the protocols have **no** controls for the effects of stress caused by differences in sediment, particle size distribution in containers without sediment.

Similarly, there are no controls for the effects of sediment physical impact and fouling on the developing oyster larvae. <u>Crassostrea gigas</u> larvae typically survive poorly when in contact with any sediment, but survive well in containers without sediment. This survivability indicates a general sediment effect. Although a reference sediment test is called for in the experimental protocols, this test is not a true control because the reference sediment is not specifically required to be of a similar particle-size distribution as the treatment sediment.

Organisms, in general, and larvae specifically, are often very particular about the sediment they choose to live in or settle upon. Mortality effects simply due to sediment physical effects are well documented (Shimek 1986, Strathmann 1987). Using these bioassay organisms, in conjunction with inappropriate sediments without appropriate controls, will give spurious and unreliable results.

The fact that these tests are unreliable as adequate indicators of biological effects is particularly noticeable in some of the results of this study. Station T4-2 sediments had very high concentrations of several of the metals. In addition, these sediments caused substantial mortality of the test organisms in the amphipod bioassay. Those data would suggest that the contaminants were substantially depressing the marine benthic community found at this station. Station T4-2, however, had the highest per area biomass of any of the sampled stations, including the reference areas. In addition, 9860 organisms representing 192 taxa were collected there. Furthermore, of those 9860 organism, more than 1000 were amphipods. These data indicate that the bioassay test organism was inappropriate to the sediment tested.

A similarly useful comparison can be made with sediment from stations T6-3 and T8-4. The concentrations in the sediment from Station T6-3 and T8-4 for Arsenic (2550:55 ppm), Copper (1203:70 ppm), Lead (2223:62 ppm), and Zinc (5800:143 ppm) were different. Nevertheless, the number of taxa found(205:208), the number of individual organisms found (5146:5418), and the biomass per unit area (80.2: 91.3 g/m²) were close to identical in the two sites.

TABLE 4-8a. Dominant taxa and community population parameters for station T2-5.

		MEAN NUMBER		
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STANDARD DEVIATION	TOTAL	PERCENT
Ampelisca agassizi	ARTH	92.50 +/- 71.89	9.95	9.95
Olivella baetica	MOLL	92.50 +/- 72.93	9.95	19.89
Diopatra ornata	ANN	47.50 +/- 28.61	5.11	25.00
Polydora pygidialis	ANN	37.50 +/- 28.61	4.03	29.03
Pholoides aspera	ANN	37.50 +/- 35.62	4.03	33.06
Prionospio steenstrupi	ANN	37.50 +/- 24.87	4.03	37.10
Odontosyllis phosphorea	ANN	37.50 +/- 24.87	4.03	41.13
Nephtys ferruginea	ANN	35.00 +/- 8.66	3.76	44.89
Hiatella arctica	MOLL	22.50 +/- 17.85	2.42	47.31
Cirratulus cirratus	ANN	22.50 +/- 28.61	2.42	49.73
Spiophanes bombyx	ANN	20.00 +/- 24.49	2.15	51.88
Pinnixa cf. schmitti	ARTH	20.00 +/- 12.25	2.15	54.03
Ophelina breviata	ANN	20.00 +/- 7.07	2.15	56.18
Spiochaetopterus costerum	ANN	15.00 +/- 15.00	1.61	57.80
Polycirrus sp. complex	ANN	15.00 +/- 11.18	1.61	59.41
Ischyrocerus sp. Indet.	ARTH	12.50 +/- 10.90	1.34	60.75
Jasminaria pacifica	ANN	12.50 +/- 16.39	1.34	62.10
Lepidonotus squamatus	ANN	10.00 +/- 7.07	1.08	63.17
Aoroides intermedius	ARTH	10.00 +/- 17.32	1.08	64.25
Spio sp. Indet.	ANN	10.00 +/- 7.07	1.08	65.32
Nemertea sp. Indet.	MISC	10.00 +/- 0.00	1.08	66.40
Nereis sp. Juv	ANN	10.00 +/- 7.07	1.08	67.47
Glycera capitata	ANN	10.00 +/- 7.07	1.08	68.55
Tharyx multifilis	ANN	10.00 +/- 7.07	1.08	69.62
Spio butleri		7.50 +/- 12.99	0.81	70.43
-	ANN	•	0.81	71.24
Cucumaria sp. 1 Indet.	MISC	7.50 +/- 8.29		71.24 72.04
Ampharetidae sp. Indet.	ANN	7.50 +/- 4.33	0.81	
Caulleriella hamata	ANN	7.50 +/- 8.29	0.81	72.85
Mediomastus sp. Indet.	ANN	7.50 +/- 8.29	0.81	73.66
Protomedeia sp. Indet.	ARTH	5.00 +/- 8.66	0.54	74.19
Solasteridae sp. Indet.	MISC	5.00 +/- 5.00	0.54	74.73
Pleurogonium rubicundum	ARTH	5.00 +/- 8.66	0.54	75.27
Synchelidium shoemakeri	ARTH	5.00 +/- 5.00	0.54	75.81
Amphiporus sp. Indet.	MISC	5.00 +/- 8.66	0.54	76.34
Microjassa sp. Indet.	ARTH	5.00 +/- 5.00	0.54	76.88
Amphiodia urtica	MISC	5.00 +/- 8.66	0.54	77.42
Barantolla americana	ANN	5.00 +/- 5.00	0.54	<b>7</b> 7.96
Tritella pilimana	ARTH	5.00 +/- 5.00	0.54	78.49
Metaphoxus frequens	ARTH	5.00 +/- 5.00	0.54	79.03
Laphania boecki	ANN	5.00 +/- 8.66	0.54	<b>7</b> 9. <b>5</b> 7
Maldane glebifex	ANN	5.00 +/- 8.66	0.54	80.11
Eupentacta pseudoquinquesemita	MISC	5.00 +/- 5.00	0.54	80.65
Stenothoidae sp. Indet.	ARTH	5.00 +/- 5.00	0.54	81.18
Mogula sp. Indet.	MISC	5.00 +/- 8.66	0.54	81.72
Mediomastus californiensis	ANN	5.00 +/- 8.66	0.54	82.26

TABLE 4-8a. Dominant taxa and community population parameters for station T2-5.

	- <del>-</del>	MEAN NU	MBER	, ·	
	MAJOR	PER SQUAR	E METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1STANDARD	DEVIATION	TOTAL	PERCENT
Margarites sp. Indet.	MOLL	5.00 +/-	8.66	0.54	82.80
Caprella striata	ARTH	5.00 +/-	8.66	0.54	83.33
Balcis sp. Indet.	MOLL	5.00 +/-	8.66	0.54	83.87
Pachycerianthus fimbriatus	MISC	5.00 +/-	5.00	0.54	84.41
Alia gausapata	MOLL	5.00 +/-	5.00	0.54	84.95
Prionospio lighti	ANN	5.00 +/-	8.66	0.54	85.48
Notomastus tenuis	ANN	5.00 +/-	5.00	0.54	86.02
Harmothoe sp. Indet.	ANN	5.00 +/-	8.66	0.54	86.56
Micropodarke dubia	ANN	5.00 +/-	5.00	0.54	87.10
Modiolus rectus	MOLL	2.50 +/-	4.33	0.27	87.37
Decamastus gracilis	ANN	2.50 +/-	4.33	0.27	87.63
Nudibranchia sp. Indet.	MOLL	2.50 +/-	4.33	0.27	87.90
Hippomedon sp. Indet.	ARTH	2.50 +/-	4.33	0.27	88.17
Pilargis berkeleyae	ANN	2.50 +/-	4.33	0.27	88.44
Opisa tridentata	ARTH	2.50 +/-	4.33	0.27	88.71
Nemocardium centifilosum	MOLL	2.50 +/-	4.33	0.27	88.98
Goniada brunnea	ANN	2.50 +/-	4.33	0.27	89.25
Sabellidae sp. Indet.	ANN	2.50 +/-	4.33	0.27	89.52
Pachynus barnardi	ARTH	2.50 +/-	4.33	0.27	89.78
Lanassa venusta venusta	ANN	2.50 +/-	4.33	0.27	90.05
Remaining taxa	37	92.5		9.95	
TOTAL =	102 Taxa	930.00 +/-	290.09		
SIMPSON'S INDEX =		0.042 +/-	0.009		
SHANNON-WIENER INDEX =		3.333 +/-	0.141		
J (EVENESS) =		0.721			

TABLE 4-8b. Dominant taxa and community population parameters for station T3-5.

<del></del>		MEAN NUM	BER	<del></del>	
	MAJOR	PER SQUARE M		PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STANDARD DI		TOTAL	PERCENT
				<del></del>	_
Tritella pilimana	ARTH	124.00 +/- 10	09.29	6.84	6.84
Diopatra ornata	ANN	•	39.29	6.28	13.12
Aoroides intermedius	ARTH	•	83.28	6.17	19.29
Pholoides aspera	ANN	•	88.41	5.95	25.25
Notomastus tenuis	ANN	•	94.95	4.52	29.77
Prionospio steenstrupi	ANN	•	96.83	4.30	34.07
Nassarius mendicus	MOLL	68.00 +/-	40.69	3.75	37.82
Odontosyllis phosphorea	ANN	•	87.95	3.42	41.23
Photis brevipes	ARTH	•	84.00	2.32	43.55
Paradulichia typica	ARTH	· ·	33.70	2.32	45.87
Odostomia (Chrysallida) sp. Indet.	MOLL	· · · · · · · · · · · · · · · · · · ·	40.50	2.21	48.07
Mediomastus sp. Indet.	ANN	•	21.91	1.65	49.72
Terebratalia transversa	MISC		32.86	1.65	51.38
Pinnixa cf. schmitti	ARTH	· ·	17.20	1.54	52.92
Eumida sanguinea	ANN	•	21.35	1.54	54.47
Sabellidae sp. Indet.	ANN	•	23.15	1.54	56.01
Spiochaetopterus costerum	ANN	·	42.71	1.43	57.44
Phoronopsis harmeri	MISC	•	23.32	1.32	58.77
Hippomedon sp. Indet.	ARTH	•	16.00	1.21	59.98
Nephtys ferruginea	ANN	•	20.40	1.21	61.19
Macoma sp. Indet.	MOLL	•	18.97	1.10	62.29
Protomedeia sp. Indet.	ARTH	·	10.95	1.10	63.40
Ocenebra sp. Indet.	MOLL	•	18.97	1.10	64.50
Solasteridae sp. Indet.	MISC	•	17.89	1.10	65.60
Golfingia sp. Indet.	MISC	•	22.27	0.99	66.59
Unidentified egg	MISC	•	24.00	0.99	67.59
Stenothoidae sp. Indet.	ARTH	•	18.33	0.99	68.58
Odostomia (Odostomia) sp. Indet.	MOLL	•	22.27	0.99	69.57
Ampelisca agassizi	ARTH	•	20.59	0.88	70.45
Cirratulus cirratus	ANN	•	19.60	0.88	71.33
Polydora socialis	ANN		17.44	0.77	72.11
Goniada brunnea	ANN	14.00 +/- 1	12.00	0.77	72.88
Cucumaria sp. 1 Indet.	MISC	12.00 +/-	7.48	0.66	73.54
Leptognathia gracilis	ARTH	12.00 +/-	7.48	0.66	74.20
Pentamera populifera	MISC		24.00	0.66	74.86
Eusyllis assimilis	ANN		19.39	0.66	75.52
Lepidonotus squamatus	ANN	•	19.39	0.66	76.19
Aeolidacea sp. Indet.	MOLL	•	10.95	0.55	76.74
Dyopedos sp. Indet.	ARTH	10.00 +/-	8.94	0.55	<i>7</i> 7.29
Dulichia cf. falcata	ARTH	10.00 +/- 1	L5.49	0.55	77.84
Paraprionospio pinnata	ANN		12.65	0.55	78.39
Prionospio lighti	ANN		10.95	0.55	<b>7</b> 8.94
Pentamera sp. Indet.	MISC	10.00 +/- 1	12.65	0.55	<b>7</b> 9.49
Byblis valeronis	ARTH	8.00 +/- 1	16.00	0.44	79.93
Polynoidae sp. Indet.	ANN	·	9.80	0.44	80.37
-		,			

TABLE 4-8b. Dominant taxa and community population parameters for station T3-5.

	····	MEAN N	IUMBER		······································
	MAJOR	PER SQUAR	PERCENT OF	CUMULATIVE	
DOMINANT TAXA	TAXON	+/-1STANDAR	D DEVIATION	TOTAL	PERCENT
Syllis heterochaeta	ANN	8.00 +/	- 11.66	0.44	80.82
Jasminaria pacifica	ANN	8.00 +/		0.44	81.26
Anobothrus gracilis	ANN	8.00 +/		0.44	81.70
Maldanidae sp. Indet.	ANN	8.00 +/		0.44	82.14
Pista brevibranchiata	ANN	8.00 +/		0.44	82.58
Tharyx multifilis	ANN	8.00 +/		0.44	83.02
Phyllodoce groenlandica	ANN	8.00 +/		0.44	83.46
Micropodarke dubia	ANN	8.00 +/-		0.44	83.90
Nuculana fossa	MOLL	8.00 +/-		0.44	84.34
Terebellidae sp. Indet.	ANN	8.00 +/		0.44	84.79
Pholoe minuta	ANN	8.00 +/-		0.44	85.23
Galathowenia oculata	ANN	8.00 +/-		0.44	85.67
Lumbrineris sp. Indet.	ANN	6.00 +/-		0.33	86.00
Ampharete acutifrons	ANN	6.00 +/-		0.33	86.33
Balanus sp. Indet. (juvenile)	ARTH	6.00 +/-		0.33	86.66
Schistocomus hiltoni	ANN	6.00 +/-		0.33	86.99
Rhodine bitorquata	ANN	6.00 +/-		0.33	87.32
Magelona longicornis	ANN	6.00 +/-	•	0.33	87.65
Halacaridae sp. Indet.	ARTH	6.00 +/-		0.33	87.98
Ampharetidae sp. Indet.	ANN	6.00 +/		0.33	88.31
Rutiderma lomae	ARTH	6.00 +/-		0.33	88.64
Fabia subquadrata	ARTH	6.00 +/-		0.33	88.97
Leptochelia savignyi	ARTH	4.00 +/-		0.22	89.20
Cerebratulus sp. 1.	MISC	4.00 +/-		0.22	89.42
Dorvillea rudolphi	ANN	4.00 +/-		0.22	89.64
Spiophanes berkeleyorum	ANN	4.00 +/-		0.22	89.86
Gammaridea sp. Indet.	ARTH	4.00 +/-		0.22	90.08
Remaining taxa	71	180		9.92	
TOTAL =	143 Taxa	1814.00 +/-	- 1074.53		
SIMPSON'S INDEX =		0.044 +/-	0.013		
SHANNON-WIENER INDEX =		3.415 +/-	0.351		
J (EVENESS) =		0.688			

TABLE 4-8c. Dominant taxa and community population parameters for station T4-2.

		MEAN NUMBE		
	MAJOR	PER SQUARE MET		CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STANDARD DEV	IATION TOTAL	PERCENT
Pholoides aspera	ANN	2352.00 +/- 874.5	54 23.85	23.85
Modiolus rectus	MOLL	788.00 +/- 118.5		31.85
Tritella pilimana	ARTH	772.00 +/- 559.6		39.68
Pinnixa cf. schmitti	ARTH	768.00 +/- 365.6		47.46
Polydora cardalia	ANN	530.00 +/- 484.1		52.84
Eusyllis assimilis	ANN	446.00 +/- 494.0		57.36
Polynoidae sp. Indet.	ANN	332.00 +/- 89.7		60.73
Polydora brachycephala	ANN	242.00 +/- 479.0		63.18
Bryozoa-Cheilostomata-Anasca sp. Indet.	MISC	138.00 +/- 112.3		64.58
Glycera capitata	ANN	136.00 +/- 33.8		65.96
Ampelisca lobata	ARTH	134.00 +/- 161.3		67.32
Eumida sanguinea	ANN	128.00 +/- 113.0		68.62
Ophiura lutkeni	MISC	126.00 +/- 44.9		69.90
Plumulariidae sp. Indet.	MISC	•		71.08
Spiochaetopterus costerum		•		72.21
Eupentacta sp. Indet.	ANN	•		73.18
Owenia fusiformis	MISC	96.00 +/- 90.0		73.18 74.10
	ANN	90.00 +/- 41.4	· · · · · · · · · · · · · · · · · · ·	
Polydora socialis	ANN	90.00 +/- 35.7		75.01
Ampelisca agassizi	ARTH	74.00 +/- 43.6		75.76
Kronborgia pugettensis	MISC	72.00 +/- 45.7		76.49
Byblis cf. millsi	ARTH	70.00 +/- 38.9		77.20
Bittium sp. Indet.	MOLL	68.00 +/- 51.9		77.89
Balanus crenatus	ARTH	68.00 +/- 107.0		78.58
Odontosyllis phosphorea	ANN	64.00 +/- 24.1		79.23
Sabella media	ANN	60.00 +/- 31.6		79.84
Photis sp. Indet.	ARTH	56.00 +/- 42.7		80.41
Hiatella arctica	MOLL	56.00 +/- 73.1		80.97
Lepidonotus squamatus	ANN	52.00 +/- 41.1		81.50
Rutiderma Iomae	ARTH	50.00 +/- 24.4		82.01
Eupentacta pseudoquinquesemita	MISC	48.00 +/- 16.0		82.49
Tiron biocellata	ARTH	48.00 +/- 30.5		82.98
Porifera sp. Indet.	MISC	46.00 +/- 40.7		83.45
Aglaja sp. Indet.	MOLL	46.00 +/- 33.8		83.91
Opheliidae sp. Indet.	ANN	46.00 +/- 45.8		84.38
Pinnotheridae sp. Indet. (larvae)	ARTH	44.00 +/- 36.1	1 0.45	84.83
Balanus sp. Indet. (juvenile)	ARTH	38.00 +/- 21.3	5 0.39	85.21
Prionospio steenstrupi	ANN	38.00 +/- 29.9	3 0.39	85.60
Pugettia gracilis	ARTH	36.00 +/- 27.2	8 0.37	85.96
Eulalia bilineata	ANN	34.00 +/- 12.0	0 0.34	86.31
Leptognathia gracilis	ARTH	32.00 +/- 59.1	3 0.32	86.63
Mediomastus sp. Indet.	ANN	32.00 +/- 21.3	5 0.32	86.96
Golfingia sp. Indet.	MISC	32.00 +/- 11.6	6 0.32	87.28
Prionospio lighti	ANN	32.00 +/- 44.9	0 0.32	87.61
	4 N TN T	·	7 0.22	87.93
Tharyx sp. Indet.	ANN	32.00 +/- 31.8	7 0.32	67.93

TABLE 4-8c. Dominant taxa and community population parameters for station T4-2.

MEAN NUMBER							
	MAJOR	PER SQUARE	E METER	PERCENT OF	CUMULATIVE		
DOMINANT TAXA	TAXON	+/-1 STANDARD	DEVIATION	TOTAL	PERCENT		
			• •				
Diopatra ornata	ANN	30.00 +/-	20.98	0.30	88.54		
Crepipatella lingulata	MOLL	30.00 +/-	6.32	0.30	88.84		
Sabellidae sp. Indet.	ANN	30.00 +/-	16.73	0.30	89.15		
Protodorvillea gracilis	ANN	28.00 +/-	31.87	0.28	89.43		
Maldanidae sp. Indet.	ANN	28.00 +/-	18.33	0.28	89.72		
Ampelisca hancocki	ARTH	28.00 +/-	56.00	0.28	90.00		
Remaining taxa	141	986		10.00			
TOTAL =	192 Taxa	9860.00 +/-	720.14				
SIMPSON'S INDEX		0.102 +/-	0.018				
SHANNON-WIENER INDEX =		3.153 +/-	0.101				
J (EVENESS) =		0.600					

TABLE 4-8d. Dominant taxa and community population parameters for station T6-3.

Company of the Compan		MEAN NUMBER		<del></del>
	MATOR		PERCENT OF	CUMULATIVE
DOMINANT TAXA	MAJOR TAXON	PER SQUARE METER + /- 1 STANDARD DEVIATION		PERCENT
· <del></del>				
Tritella pilimana	ARTH	958.00 +/- 917.79	18.62	18.62
Pinnixa cf. schmitti	ARTH	312.00 +/- 204.49	6.06	24.68
Prionospio steenstrupi	ANN	196.00 +/- 65.60	3.81	28.49
Alia gausapata	MOLL	190.00 +/- 84.38	3.69	32.18
Eumida sanguinea	ANN	178.00 +/- 131.97	3.46	35.64
Pholoides aspera	ANN	146.00 +/- 105.19	2.84	38.48
Pandora filosa	MOLL	98.00 +/- 64.00	1.90	40.38
Semele rubropincta	MOLL	92.00 +/- 73.05	1.79	42.17
Spiochaetopterus costerum	ANN	90.00 +/- 57.62	1.75	43.92
Odontosyllis phosphorea	ANN	88.00 +/- 48.33	1.71	45.63
Cucumaria piperata	MISC	86.00 +/- 67.11	1.67	47.30
Photis sp. Indet.	ARTH	82.00 +/- 84.24	1.59	48.89
Byblis cf. millsi	ARTH	80.00 +/- 38.47	1.55	50.45
Ampelisca agassizi	ARTH	78.00 +/- 49.15	1.52	51.96
Polydora cardalia	ANN	74.00 +/- 81.14	1.44	53.40
Odostomia (Chrysallida) sp. Indet.	MOLL	74.00 +/- 87.77	1.44	54.84
Lumbrineris sp. Indet.	ANN	72.00 +/- 33.70	1.40	56.24
Aoroides intermedius	ARTH	70.00 +/- 34.06	1.36	57.60
Diopatra ornata	ANN	68.00 +/- 44.90	1.32	58.92
Bryozoa-Cheilostomata-Anasca sp. Indet.		64.00 +/- 93.51	1.24	60.16
Polydora socialis	ANN	64.00 +/- 69.46	1.24	61.41
Nephtys ferruginea	ANN	54.00 +/- 38.78	1.05	62.46
Delectopecten sp. Indet.	MOLL	52.00 +/- 39.70	1.01	63.47
Lyonsia arenosa	MOLL	50.00 +/- 60.66	0.97	64.44
Polydora pygidialis	ANN	50.00 +/- 50.99	0.97	65.41
Polynoidae sp. Indet.	ANN	46.00 +/- 22.45	0.89	66.30
Glycera capitata	ANN	44.00 +/- 22.45	0.86	67.16
Sabella media	ANN	44.00 +/- 30.07	0.86	68.01
Pycnogonida sp. Indet.	ARTH	44.00 +/- 88.00	. 0.86	68.87
Tellina nuculoides	MOLL	42.00 +/- 29.26	0.82	69.69
Anobothrus gracilis	ANN	38.00 +/- 17.20	0.74	70.42
Trichotropis cancellata	MOLL	38.00 +/- 14.70	0.74	71.16
Caprella mendax	ARTH	38.00 +/- 51.92	0.74	71.90
Bankia setacea		36.00 +/- 58.17	0.70	72.60
	MOLL	34.00 +/- 26.53	0.66	73.26
Eudorella pacifica	ARTH		0.62	73.88
Phyllodoce mucosa	ANN	•	0.62	74.50
Nuculana fossa	MOLL	32.00 +/- 27.86		75.09
Prionospio lighti	ANN	30.00 +/- 40.99	0.58	
Mediomastus californiensis	ANN	30.00 +/- 10.95	0.58	75.67 76.21
Glyceridae sp. Indet.	ANN	28.00 +/- 11.66	0.54	76.21 76.76
Owenia fusiformis	ANN	28.00 +/- 24.00	0.54	76.76
Mytilidae sp. Indet.	MOLL	26.00 +/- 30.72	0.51	77.26
Maldane glebifex	ANN	24.00 +/- 24.17	0.47	77.73
Spiophanes berkeleyorum	ANN	24.00 +/- 16.25	0.47	78.20
Crepipatella lingulata	MOLL	24.00 +/- 13.56	0.47	78.66 70.00
Eulalia bilineata	ANN	22.00 +/- 11.66	0.43	79.09

TABLE 4-8d. Dominant taxa and community population parameters for station T6-3.

DOMINANT TAXA  TAX  Ophiura lutkeni Cirratulus cirratus Lepidonotus squamatus Photis lacia Amphicteis glabra Anthozoa sp. Indet. Hippomedon sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Moi Margarites sp. Indet. Moi Pista elongata Ann Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. Gastropteron pacificum Cardiomya californica  MISC  MISC  MAN MAN MISC  ANN MISC  A	C 22.00 I 22.00 I 20.00 IH 20.00 II 20.00	+/- 34.87 +/- 26.08 +/- 20.98	0.43 0.43 0.39	CUMULATIVE PERCENT 79.52 79.95 80.33
DOMINANT TAXA  Ophiura lutkeni Cirratulus cirratus Lepidonotus squamatus Photis lacia Amphicteis glabra Anthozoa sp. Indet. Hippomedon sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Moi Margarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN ANN Piscicolidae sp. Indet. ANN ANN ANN ANN Piscicolidae sp. Indet. ANN ANN ANN Piscicolidae sp. Indet. ANN ANN ANN ANN ANN ANN ANN ANN ANN AN	C 22.00 I 22.00 I 20.00 IH 20.00 II 20.00	+/- 20.40 +/- 34.87 +/- 26.08 +/- 20.98	0.43 0.43 0.39	79.52 79.95
Cirratulus cirratus Lepidonotus squamatus Photis lacia Amphicteis glabra Anthozoa sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Margarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN ANN Piscicolidae sp. Indet. ANN ANN Piscicolidae sp. Indet. ANN ANN ANN ANN Piscicolidae sp. Indet. ANN ANN ANN ANN ANN ANN ANN ANN ANN AN	T 22.00 T 20.00 TH 20.00 T 20.00	+/- 34.87 +/- 26.08 +/- 20.98	0.43 0.39	79.95
Lepidonotus squamatus Photis lacia Amphicteis glabra Anthozoa sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Morgarites sp. Indet. Morgarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Sabellidae sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. Gastropteron pacificum Morgarites ANN Morgarites sp. Indet. Ann Notomastus tenuis Piscicolidae sp. Indet. Ann Gastropteron pacificum	TH 20.00 TH 20.00	+/- 26.08 +/- 20.98	0.39	
Photis lacia Amphicteis glabra Anthozoa sp. Indet. Hippomedon sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Margarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Osastropteron pacificum MOI	TH 20.00 I 20.00	+/- 20.98		20.22
Amphicteis glabra Anthozoa sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Margarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Otomastus tenuis Piscicolidae sp. Indet. ANN Otomastus tenuis ANN Otomastus tenuis Piscicolidae sp. Indet. ANN Otomastus tenuis	20.00	•	0.20	ou. <i>5</i> 3
Anthozoa sp. Indet. Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Margarites sp. Indet. Moltoniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Otomastus tenuis ANN Piscicolidae sp. Indet. ANN Otomastus tenuis		± / <sub>-</sub> 14 14	0.39	80.72
Hippomedon sp. Indet. Tharyx multifilis Terebellidae sp. Indet. Margarites sp. Indet. Mol Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Gastropteron pacificum ANN Mol	20.00	17 17.17	0.39	81.11
Tharyx multifilis Terebellidae sp. Indet. Margarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Otomastus tenuis Piscicolidae sp. Indet. ANN Otomastus tenuis		+/- 20.98	0.39	81.50
Terebellidae sp. Indet.  Margarites sp. Indet.  Pista elongata  Goniada brunnea  Pinnotheridae sp. Indet. (larvae)  Parapleustes sp. Indet.  Onuphis elegans  Protomedeia sp. Indet.  Eupentacta pseudoquinquesemita  Eusyllis assimilis  Schistocomus hiltoni  Nemertea sp. Indet.  Sabellidae sp. Indet.  Scionella estevanica  Notomastus tenuis  Piscicolidae sp. Indet.  ANN  Gastropteron pacificum  MOI	H 20.00	+/- 14.14	0.39	81.89
Margarites sp. Indet. Pista elongata Goniada brunnea Pinnotheridae sp. Indet. (larvae) ART Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Otomastus tenuis ANN Piscicolidae sp. Indet. ANN Otomastus tenuis ANN Otomastus tenuis ANN Piscicolidae sp. Indet. ANN Otomastus tenuis	20.00	+/- 17.89	0.39	82.28
Pista elongata Goniada brunnea ANN Pinnotheridae sp. Indet. (larvae) ART Parapleustes sp. Indet. Onuphis elegans ANN Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. MISC Sabellidae sp. Indet. ANN Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. Gastropteron pacificum ANN MOI	18.00	+/- 13.27	0.35	82.63
Goniada brunnea Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Otomastus tenuis Piscicolidae sp. Indet. ANN Otomastus tenuis	LL 18.00	+/- 22.27	0.35	82.98
Pinnotheridae sp. Indet. (larvae) Parapleustes sp. Indet. Onuphis elegans ANN Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Otomastus tenuis ANN Piscicolidae sp. Indet. Gastropteron pacificum ART	18.00	+/- 36.00	0.35	83.33
Parapleustes sp. Indet. Onuphis elegans ANN Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Piscicolidae sp. Indet. ANN Otomastus tenuis ANN Piscicolidae sp. Indet. ANN Otomastus tenuis	18.00	+/- 11.66	0.35	83.68
Onuphis elegans Protomedeia sp. Indet. Eupentacta pseudoquinquesemita Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Gastropteron pacificum ANN MOI	H 18.00	+/- 13.27	0.35	84.03
Protomedeia sp. Indet.  Eupentacta pseudoquinquesemita  Eusyllis assimilis  Schistocomus hiltoni  Nemertea sp. Indet.  Sabellidae sp. Indet.  Scionella estevanica  Notomastus tenuis  Piscicolidae sp. Indet.  Gastropteron pacificum  ART  ANN  ANN  ANN  MISC  ANN  ANN  MOI	H 18.00	+/- 16.00	0.35	84.38
Protomedeia sp. Indet.  Eupentacta pseudoquinquesemita  Eusyllis assimilis  Schistocomus hiltoni  Nemertea sp. Indet.  Sabellidae sp. Indet.  Scionella estevanica  Notomastus tenuis  Piscicolidae sp. Indet.  Gastropteron pacificum  ART  ANN  ANN  ANN  MISC  ANN  ANN  MOI	18.00	+/- 4.00	0.35	84.73
Eusyllis assimilis Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Gastropteron pacificum ANN MOI		•	0.35	85.08
Schistocomus hiltoni Nemertea sp. Indet. Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. Gastropteron pacificum ANN MOI	18.00	+/- 11.66	0.35	85.43
Nemertea sp. Indet.  Sabellidae sp. Indet.  Scionella estevanica  Notomastus tenuis  Piscicolidae sp. Indet.  Gastropteron pacificum  MISC  ANN  ANN  MISC  MISC  ANN  MISC  ANN  MISC  MISC  ANN  MISC  MISC  MISC  MISC  ANN  MISC  M		· · · · ·	0.31	85.74
Sabellidae sp. Indet. Scionella estevanica Notomastus tenuis Piscicolidae sp. Indet. ANN Gastropteron pacificum ANN MOI	16.00	+/- 22.45	0.31	86.05
Scionella estevanica ANN Notomastus tenuis ANN Piscicolidae sp. Indet. ANN Gastropteron pacificum MOI	C 16.00	+/- 14.97	0.31	86.36
Notomastus tenuis ANN Piscicolidae sp. Indet. ANN Gastropteron pacificum MOI	16.00	+/- 16.25	0.31	86.67
Piscicolidae sp. Indet. ANN Gastropteron pacificum MOI	14.00	+/- 13.56	0.27	86.94
Gastropteron pacificum MOI	14.00	+/- 13.56	0.27	87.21
• •	14.00	+/- 19.60	0.27	87,49
Cardiomya californica MOI	L 12.00	+/- 14.70	0.23	87. <b>72</b>
	L 12.00	+/- 16.00	0.23	87.95
Thelepus setosa ANN	12.00	+/- 11.66	0.23	88.18
Caulleriella hamata ANN	12.00	+/- 9.80	0.23	88.42
Mesochaetopterus taylori ANN	12.00	+/- 9.80	0.23	88.65
Scionella japonica ANN	12.00	+/- 7.48	0.23	88.88
Potamilla occelata ANN	12.00	+/- 14.70	0.23	89.12
Maldanidae sp. Indet. ANN		-	0.23	89.35
Phyllodocide sp. Indet. ANN		+/- 9.80	0.23	89. <b>5</b> 8
Terebratalia transversa MISC		+/- 11.66	0.23	89.82
Ischyrocerus sp. Indet. ART		•	0.23	90.05
Remaining taxa 12	24 512		9.95	
TOTAL = 205 T	Γaxa 5146.00	+/- 2429.70		
SIMPSON'S INDEX	0.053	+/- 0.028		
SHANNON-WIENER INDEX	3.759	+/- 0.242		
J (EVENESS) =	0.706			

TABLE 4-8e. Dominant taxa and community population parameters for station T8-4.

		MEAN NUMBER		
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STANDARD DEVIATION	TOTAL	PERCENT
Eualus pusiolus	ARTH	396.00 +/- 205.58	7.31	7.31
Terebellides stroemi	ANN	362.00 +/- 163.88	6.68	13.99
Diastylis paraspinulosa	ARTH	292.00 +/- 115.31	5.39	19.38
Photis sp. Indet.	ARTH	284.00 +/- 83.09	5.24	24.62
Euphilomedes carcharodonta	ARTH	206.00 +/- 74.73	3.80	28.42
Porifera sp. Indet.	MISC	186.00 +/- 78.89	3.43	31.86
Nucula tenuis	MOLL	174.00 +/- 72.83	3.21	35.07
Astarte alaskensis	MOLL	140.00 +/- 98.99	2.58	37.65
Pachycerianthus fimbriatus	MISC	122.00 +/- 56.36	2.25	39.90
Tiron biocellata	ARTH	110.00 +/- 69.28	2.03	41.93
Prionospio lighti	ANN	106.00 +/- 131.85	1.96	<b>43.8</b> 9
Sabella media	ANN	106.00 +/- 172.35	1.96	45.85
Onuphis sp. Juv.	ANN	104.00 +/- 38.26	1.92	47.77
Turbellaria-Kalyptorhynchia sp. Indet.	MISC	100.00 +/- 35.78	1.85	49.61
Synidotea angulata	ARTH	96.00 +/- 49.23	1.77	51.38
Velutina velutina	MOLL	90.00 +/- 72.39	1.66	53.05
Pista brevibranchiata	ANN	90.00 +/- 51.77	1.66	54.71
Cnidaria sp. Indet.	MISC	86.00 +/- 32.62	1.59	56.29
Harmothoe nr. H. lunulata	ANN	84.00 +/- 126.59	1.55	57.84
Spionidae sp. Indet.	ANN	72.00 +/- 27.86	1.33	59.17
Pagurus sp. Indet.	ARTH	70.00 +/- 34.06	1.29	60.47
Axinopsida serricata	MOLL	70.00 +/- 26.08	1.29	61.76
Amphicteis glabra	ANN	68.00 +/- 50.36	1.26	63.01
Praxillella affinis pacifica	ANN	66.00 +/- 52.76	1.22	64.23
Hippolytidae sp. Indet.	ARTH	64.00 +/- 78.13	1.18	65.41
Harmothoe imbricata	ANN	62.00 +/- 35.44	1.14	66.56
Semele rubropincta	MOLL	60.00 +/- 28.98	1.11	67.66
Scalpellum columbianum	ARTH	50.00 +/- 10.95	0.92	68.59
Rhynchothalestris helgolandica	ARTH	46.00 +/- 34.41	0.85	69.44
Pentamera populifera	MISC	44.00 +/- 25.77	0.81	70.25
Trochochaeta multisetosa	ANN	42.00 +/- 27.86	0.78	71.02
Parapleustes sp. Indet.	ARTH	42.00 +/- 38.68	0.78	71.80
Eteone californica	ANN	40.00 +/- 15.49	0.74	72.54
Eupentacta pseudoquinquesemita	MISC	38.00 +/- 19.39	0.70	73.24
Caulleriella hamata	ANN	38.00 +/- 29.93	0.70	73.94
Phoronida sp. Indet.	MISC	36.00 +/- 12.00	0.66	74.60
Fabia subquadrata	ARTH	36.00 +/- 12.00	0.66	75.27
Caprella striata	ARTH	34.00 +/- 10.20	0.63	75.90 ·
Anthozoa sp. Indet.	MISC	32.00 +/- 36.55	0.59	76.49
Eulalia levicornuta	ANN	32.00 +/- 4.00	0.59	77.08
Crepipatella lingulata	MOLL	32.00 +/- 4.00	0.59	77.67
Notomastus lineatus	ANN	32.00 +/- 24.82	0.59	77.07 78.26
Solen sicarius	MOLL	30.00 +/- 22.80	0.55	78.81
	ARTH	28.00 +/- 22.80	0.52	79.33
Gammaropsis thompsoni Laphania boecki	ANN	26.00 +/- 17.44	0.48	79.81
Chaetozone setosa	ANN	26.00 +/- 32.62	0.48	80.29
Chactozone setosa	W111	20.00 1/- 32.02	0.10	30.22

TABLE 4-8e. Dominant taxa and community population parameters for station T8-4.

		1			
	MAJOR	PER SQUAF	UMBER RE METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/- 1 STANDAR		TOTAL	PERCENT
Bankia setacea	MOLL	24.00 +/-	- 10.20	0.44	80.73
Euphilomedes producta	ARTH	22.00 +/-	- 17.20	0.41	81.14
Cumacea sp. Indet.	ARTH	20.00 +/-	- 22.80	0.37	81.51
Cirratulus spectabilis	ANN	20.00 +/-	16.73	0.37	81.88
Macoma yoldifomis	MOLL	20.00 +/-		0.37	82.24
Podocerus cristatus	ARTH	20.00 +/-	35.21	0.37	82.61
Exogone lourei	ANN	20.00 +/-	14.14	0.37	82.98
Pista moorei	ANN	18.00 +/-		0.33	83.31
Gastropteron pacificum	MOLL	18.00 +/-		0.33	83.65
Platyhelminthes	MISC	18.00 +/-		0.33	83.98
Nudibranchia sp. Indet.	MOLL	18.00 +/-		0.33	84.31
Balanus sp. Indet. (juvenile)	ARTH	18.00 +/-		0.33	84.64
Pista sp. Indet.	ANN	18.00 +/-		0.33	84.98
Spio sp. Indet.	ANN	16.00 +/-		0.30	85.27
Lepidasthenia longicirrata	ANN	16.00 +/-		0.30	85.57
Sthenelais tertiaglabra	ANN	16.00 +/-		0.30	85.86
Odontosyllis phosphorea	ANN	16.00 +/-		0.30	86.16
Nemertea-Enopla sp. Indet.	MISC	14.00 +/-		0.26	86.42
Lophopanopeus (megalops)	ARTH	14.00 +/-		0.26	86.67
Tellina nuculoides	MOLL	14.00 +/-		0.26	86.93
Dorvillea japonica	ANN	14.00 +/-		0.26	87.19
Photis brevipes	ARTH	14.00 +/-		0.26	87.45
Myriochele heeri	ANN	12.00 +/-		0.22	87.67
Orchomene pacifica	ARTH	12.00 +/-		0.22	87.89
Serpulidae sp. Indet.	ANN	12.00 +/-		0.22	88.11
Melphisana sp. Indet.	ARTH	12.00 +/-		0.22	88.34
Harmothoe sp. Indet.	ANN	12.00 +/-		0.22	88.56
Macoma obliqua	MOLL	12.00 +/-		0.22	88.78
Decamastus gracilis	ANN	12.00 +/-		0.22	89.00
Ampelisca lobata	ARTH	12.00 +/-		0.22	89.22
Lepidonotus squamatus	ANN	12.00 +/-		0.22	89.44
Paraonidae sp. Indet.	ANN	12.00 +/-		0.22	89.66
Mytilidae sp. Indet.	MOLL	12.00 +/-		0.22	89.89
Lucinoma acutilineata	MOLL	12.00 +/-		0.22	90.11
Remaining taxa	128	536		9.89	
TOTAL =	208 Taxa	5418.00 +/-	1410.72		
SIMPSON'S INDEX =		0.030 +/-	0.004		
SHANNON-WIENER INDEX =		3.967 +/-	0.073		
J (EVENESS) =		0.743			

TABLE 4-8f. Dominant taxa and community population parameters for station T10-1.

		MEAN N			
	MAJOR	PER SQUAR	E METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STANDARI	DEVIATION	TOTAL	PERCENT
Rhynchothalestris helgolandica	ARTH	912.00 +/-	105.34	16.80	16.80
Paleonotus bellis	ANN	654.00 +/-		12.05	28.85
Pista brevibranchiata	ANN	424.00 +/-		7.81	36.66
Heteromastus sp. Indet.	ANN	392.00 +/-		7.22	43.88
Notomastus tenuis	ANN	308.00 +/-		5.67	49.56
Tiron biocellata	ARTH	218.00 +/-		4.02	53.57
Spio sp. Indet.	ANN	168.00 +/-		3.10	56.67
Photis brevipes	ARTH	148.00 +/-		2.73	59.40
Sigambra tentaculata	ANN	128.00 +/-		2.36	61.75
Modiolus rectus	MOLL	124.00 +/-	140.66	2.28	64.04
Crustacea sp. Indet.	ARTH	116.00 +/-	71.44	2.14	66.18
Glyceridae sp. Indet.	ANN	114.00 +/-	90.02	2.10	68.28
Harmothoe imbricata	ANN	108.00 +/-	72.50	1.99	70.27
Cerebratulus sp. 1.	MISC	108.00 +/-		1.99	72.25
Lepidasthenia longicirrata	ANN	104.00 +/-	42.24	1.92	74.17
Piscicolidae sp. Indet.	ANN	94.00 +/-	99.32	1.73	75.90
Sthenelais tertiaglabra	ANN	92.00 +/-		1.69	77.60
Proclea graffii	ANN	80.00 +/-	26.08	1.47	79.07
Ampelisca hancocki	ARTH	78.00 +/-	31.24	1.44	80.51
Harmothoe sp. Indet.	ANN	64.00 +/-	37.20	1.18	81.69
Eualus pusiolus	ARTH	60.00 +/-	28.28	1.11	82.79
Sthenelais berkeleyi	ANN	56.00 +/-	73.38	1.03	83.82
Strongylocentrotus sp. Indet.	MISC	56.00 +/-	44.54	1.03	84.86
Turbellaria-Kalyptorhynchia sp. Indet.	MISC	52.00 +/-	21.35	0.96	85.81
Isaeidae sp. Indet.	ARTH	50.00 +/-	16.73	0.92	86.74
Ampharetidae sp. Indet.	ANN	38.00 +/-	21.35	0.70	87.44
Compsomyax subdiaphana	MOLL	38.00 +/-	23.15	0.70	88.14
Terebellides stroemi	ANN	34.00 +/-	20.59	0.63	88.76
Corophium sp. Indet.	ARTH	34.00 +/-	58.51	0.63	89.39
Ischnochitonidae sp. Indet.	MOLL	30.00 +/-	26.83	0.55	89.94
Parapleustes sp. Indet.	ARTH	30.00 +/-	17.89	0.55	90.49
Remaining taxa	81	516		9.51	
TOTAL =	112 Taxa	5428.00 +/-	509.41		
SIMPSON'S INDEX =		0.072 +/-	0.011		٠.
SHANNON-WIENER INDEX =		3.153 +/-	0.165		
J (EVENESS) =		0.668			

TABLE 4-8g. Dominant taxa and community population parameters for station T11-7.

	MEAN NUMBER						
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE			
DOMINANT TAXA	TAXON	+/- 1 STANDARD DEVIATION	TOTAL	PERCENT			
<b>—</b> • • • • • • • • • • • • • • • • • • •							
Porifera sp. Indet.	MISC	182.00 +/- 50.36	19.96	19.96			
Hydroida (encrusting) sp. Indet.	MISC	130.00 +/- 46.48	14.25	34.21			
Cnidaria sp. Indet.	MISC	66.00 +/- 36.11	7.24	41.45			
Platyhelminthes	MISC	42.00 +/- 25.61	4.61	46.05			
Obelia sp. Indet.	MISC	32.00 +/- 25.61	3.51	49.56			
Thuiaria sp. Indet.	MISC	28.00 +/- 16.00	3.07	52.63			
Harmothoe imbricata	· ANN	26.00 +/- 47.16	2.85	55.48			
Pachycerianthus fimbriatus	MISC	20.00 +/- 30.98	2.19	57.68			
Sertulariidae sp. Indet.	MISC	20.00 +/- 20.98	2.19	59.87			
Ischyrocerus sp. Indet.	ARTH	18.00 +/- 36.00	1.97	61.84			
Eualus pusiolus	ARTH	18.00 +/- 22.27	1.97	63.82			
Polycladida sp. Indet.	MISC	18.00 +/- 7.48	1.97	65.79			
Tiron biocellata	ARTH	16.00 +/- 22.45	1.75	67.54			
Turbellaria-Kalyptorhynchia sp. Indet.	MISC	14.00 +/- 23.32	1.54	69.08			
Plumulariidae sp. Indet.	MISC	14.00 +/- 13.56	1.54	70.61			
Onuphis sp. Juv.	ANN	12.00 +/- 11.66	1.32	71.93			
Odontosyllis phosphorea	ANN	12.00 +/- 11.66	1.32	73.25			
Diastylis paraspinulosa	ARTH	10.00 +/- 20.00	1.10	74.34			
Anthozoa sp. Indet.	MISC	10.00 +/- 6.32	1.10	75.44			
Pista brevibranchiata	ANN	8.00 +/- 16.00	0.88	76.32			
Nemertea-Enopla sp. Indet.	MISC	8.00 +/- 4.00	0.88	<i>7</i> 7.19			
Adontorhina cyclia	MOLL	8.00 +/- 16.00	0.88	78.07			
Gastropteron pacificum	MOLL	8.00 +/- 16.00	0.88	78.95			
Halcampa decemententaculata	MISC	8.00 +/- 7.48	0.88	79.82			
Caprella striata	ARTH	8.00 +/- 9.80	0.88	80.70			
Lepidasthenia longicirrata	ANN	6.00 +/- 4.90	0.66	81.36			
Spionidae sp. Indet.	ANN	6.00 +/- 8.00	0.66	82.02			
Lepidonotus squamatus	ANN	6.00 +/- 8.00	0.66	82.68			
Paranaitis polynoides	ANN	4.00 +/- 4.90	0.44	83.11			
Hiatella arctica	MOLL	4.00 +/- 8.00	0.44	83.55			
Tenonia kitsapensis	ANN	4.00 +/- 4.90	0.44	83.99			
Galathowenia oculata	ANN	4.00 +/- 8.00	0.44	84.43			
Cerebratulus sp. 1.	MISC	4.00 +/- 4.90	0.44	84.87			
Fabia subquadrata	ARTH	4.00 +/- 8.00	0.44	85.31			
Harmothoe sp. Indet.	ANN	4.00 +/- 4.90	0.44	85.75			
Paleonotus bellis	ANN	4.00 +/- 8.00	0.44	86.18			
Amphiporus sp. Indet.	MISC	4.00 +/- 4.90	0.44	86.62			
Callianassa sp. Indet. (juvenile)	ARTH	4.00 +/- 4.90	0.44	87.06			
Halosydna brevisetosa	ANN	4.00 +/- 4.90	0.44	87.50			
Leitoscoloplos pugettensis	ANN	4.00 +/- 8.00	0.44	87.94			

TABLE 4-8g. Dominant taxa and community population parameters for station T11-7.

	*	MEAN	NU	MBER			
	MAJOR	PER SQUA	RE	METER	PERCENT OF	CUMULATIVE	
DOMINANT TAXA	TAXON	+/- 1 STANDA	RD	DEVIATION	TOTAL	PERCENT	
Euphilomedes carcharodonta	ARTH	4.00 +	/-	8.00	0.44	88.38	
Phyllodocide sp. Indet.	ANN	4.00 +	/-	4.90	0.44	88.82	
Asychis similis	ANN	4.00 +	/ <b>-</b>	4.90	0.44	89:25	
Praxillella affinis pacifica	ANN	4.00 +	/-	8.00	0.44	89.69	
Dexamonica reduncans	ARTH	4.00 +	/-	8.00	0.44	90.13	
Remaining taxa	45	90			9.87		
TOTAL =	90 Taxa	912.00 +	/-	284.84			
SIMPSON'S INDEX =		0.097 +	/-	0.032			
SHANNON-WIENER INDEX =		2.775 +	/-	0.386			
J (EVENESS) =		0.617					

TABLE 4-8h. Dominant taxa and community population parameters for station T12-1.

		MEAN NUMBER		
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/- 1 STANDARD DEVIATION	TOTAL	PERCENT
Notomastus tenuis	ANN	9028.00 +/- 8091.54	82.89	82.89
Paleonotus bellis	ANN	490.00 +/- 583.61	4.50	87.39
Rhynchothalestris helgolandica	ARTH	214.00 +/- 196.43	1.96	89.35
Tiron biocellata	ARTH	148.00 +/- 114.44	1.36	90.71
Remaining taxa	72	1012	9.29	
TOTAL =	76 Taxa	10892.00 +/- 9027.59		
SIMPSON'S INDEX =		0.523 +/- 0.302		
SHANNON-WIENER INDEX =		1.388 +/- 0.853		
J (EVENESS) =		0.320		
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TABLE 4-8i. Dominant taxa and community population parameters for station T16-1.

		MEAN NUMBER			
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE	
DOMINANT TAXA	TAXON	+/-1 STANDARD DEVIATION	TOTAL	PERCENT	
				·	
Porifera sp. Indet.	MISC	910.00 +/- 217.81	18.76	18.76	
Euphilomedes carcharodonta	ARTH	790.00 +/- 209.38	16.28	35.04	
Cnidaria sp. Indet.	MISC	282.00 +/- 57.76	· · · · 5.81 — ·	40.85	
Tiron biocellata	ARTH	248.00 +/- 128.90	5.11	45.96	
Paraonidae sp. Indet.	ANN	166.00 +/- 137.20	3.42	49.38	
Onuphis sp. Juv.	ANN	148.00 +/- 68.53	3.05	52.43	
Unidentified egg	MISC	132.00 +/- 23.15	2.72	55.15	
Ampharete acutifrons	ANN	120.00 +/- 14.14	2.47	57.63	
Decamastus gracilis	ANN	98.00 +/- 39.70	2.02	59.65	
Thuiaria sp. Indet.	MISC	98.00 +/- 75.21	2.02	61.67	
Caprella striata	ARTH	96.00 +/- 36.11	1.98	63.64	
Syllis heterochaeta	ANN	84.00 +/- 24.17	1.73	65.38	
Eualus pusiolus	ARTH	68.00 +/- 36.55	1.40	66.78	
Pachycerianthus fimbriatus	MISC	64.00 +/- 14.97	1.32	68.10	
Harmothoe sp. Indet.	ANN	62.00 +/- 33.70	1.28	69.37	
Lyonsia arenosa	MOLL	60.00 +/- 38.99	1.24	70.61	
Turbellaria-Kalyptorhynchia sp. Indet.	MISC	58.00 +/- 17.20	1.20	71.81	
Nephtys ferruginea	ANN	56.00 +/- 29.39	1.15	72.96	
Bryozoa-Cheilostomata-Anasca sp. Indet.	MISC	48.00 +/- 44.00	0.99	73.95	
Photis sp. Indet.	ARTH	38.00 +/- 13.27	0.78	74.73	
Polydora sp. Indet.	ANN	36.00 +/- 28.71	0.74	75.47	
Pista moorei	ANN	34.00 +/- 20.59	0.70	76.17	
Solen sicarius	MOLL	32.00 +/- 16.00	0.66	76.83	
Rhynchothalestris helgolandica	ARTH	32.00 +/- 46.65	0.66	77.49	
Cirratulus cirratus	ANN	32.00 +/- 23.15	0.66	78.15	
Mediomastus californiensis	ANN	28.00 +/- 7.48	0.58	78.73	
Polycladida sp. Indet.	MISC	28.00 +/- 23.15	0.58	79.31	
Cerebratulus sp. 1.	MISC	28.00 +/- 19.39	0.58	79.88	
Amphicteis glabra	ANN	26.00 +/- 23.32	0.54	80.42	
Axinopsida serricata	MOLL	26.00 +/- 13.56	0.54	80.96	
Aoroides sp. Indet.	ARTH	26.00 +/- 8.00	0.54	81.49	
Paraprionospio pinnata	ANN	24.00 +/- 4.90	0.49	81.99	
Goniada brunnea	ANN	24.00 +/- 10.20	0.49	82.48	
Pardalisca tenuipes	ARTH	24.00 +/- 24.17	0.49	82.98	
Callianassa sp. Indet. (juvenile)	ARTH	22.00 +/- 17.20	0.45	83.43	
Ophiodromus pugettensis	ANN	22.00 +/- 44.00	0.45	83.88	
Paleonotus bellis	ANN	22.00 +/- 19.39	0.45	84.34	
Chaetopteridae sp. Indet.	ANN	20.00 +/- 26.08	0.41	84.75	
Tharyx multifilis	ANN	20.00 +/- 16.73	0.41	85.16	
Macoma yoldifomis	MOLL	20.00 +/- 18.97	0.41	85 <i>.</i> 57	
Balanus crenatus	ARTH	18.00 +/- 7.48	0.37	85.94	
Hiatella arctica	MOLL	18.00 +/- 11.66	0.37	86.31	
Corophium ascherusicum	ARTH	18.00 +/- 18.33	0.37	86.69	
Boccardia pugettensis	ANN	18.00 +/- 19.39	0.37	87.06	
Parathemisto pacifica	ARTH	18.00 +/- 24.00	0.37	87.43	
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TABLE 4-8i. Dominant taxa and community population parameters for station T16-1.

		MEAN	I NUI	MBER		
	MAJOR	PER SQU	ARE	METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STAND	ARD	DEVIATION	TOTAL	PERCENT
Hyperiidae sp. Indet. (juvenile)	ARTH	18.00	+/-	17.20	0.37	87.80
Diastylis paraspinulosa	ARTH	18.00	•		0.37	88.17
Pista brevibranchiata	ANN	18.00	•		0.37	88.54
Tubulanus sp. Indet.	MISC	16.00	•		0.33	88.87
Plumulariidae sp. Indet.	MISC	16.00	+/-	8.00	0.33	89.20
Phoxocephalidae sp. Indet.	ARTH	16.00	+/-	12.00	0.33	89.53
Musculus cf. olivaceus	MOLL	16.00	+/-	22.45	0.33	89.86
Asychis similis	ANN	14.00	+/-	4.90	0.29	90.15
Remaining taxa	90	478			9.85	
TOTAL =	143 Taxa	4852.00	+/-	863.84	4852.00	
SIMPSON'S INDEX =		0.080	+/-	0.012		
SHANNON-WIENER INDEX =		3.311	+/-	0.107		
J (EVENESS) =		0.667				

TABLE 4-8j. Dominant taxa and community population parameters for station T16-4.

· <del></del>		MEAN NUMBER		
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE
DOMINIA NET TAYA		+/-1 STANDARD DEVIATION	TOTAL	PERCENT
DOMINANT TAXA	TAXON	+/-1STANDARD DEVIATION	TOTAL	FERCENT
Prionospio steenstrupi	ANN	252.00 +/- 105.72	19.06	19.06
Clinocardium sp. Indet.	MOLL	84.00 +/- 57.83	6.35	25.42
Nephtys ferruginea	ANN	84.00 +/- 44.54	6.35	31.77
Rhepoxynius daboius	ARTH	68.00 +/- 11.66	5.14	36.91
Euphilomedes producta	ARTH	62.00 +/- 31.87	4.69	41.60
Cucumaria sp. 2 Indet.	MISC	48.00 +/- 26.38	3.63	45.23
Notomastus tenuis	ANN	38.00 +/- 19.39	2.87	48.11
Compsomyax subdiaphana	MOLL	30.00 +/- 21.91	2.27	50.38
Pectinaria californiensis	ANN	28.00 +/- 11.66	2.12	52.50
Polydora brachycephala	ANN	28.00 +/- 23.15	2.12	54.61
Diopatra ornata	ANN	26.00 +/- 18.55	1.97	56.58
Nuculana fossa	MOLL	24.00 +/- 13.56	1.82	58.40
Lyonsia arenosa	MOLL	24.00 +/- 8.00	1.82	60.21
Sabellidae sp. Indet.	ANN	20.00 +/- 18.97	1.51	61.72
Pinnixa cf. schmitti	ARTH	20.00 +/- 6.32	1.51	63.24
Myriochele heeri	ANN	18.00 +/- 11.66	1.36	64.60
Glycera capitata	ANN	·	1.36	65.96
Metaphoxus frequens		•	1.21	67.17
	ARTH	16.00 +/- 4.90		
Lumbrineris sp. Indet.	ANN	16.00 +/- 13.56	1.21	68.38
Tharyx multifilis Amphicteis glabra	ANN	16.00 +/- 8.00	1.21	69.59 70.80
	ANN	16.00 +/- 4.90	1.21	70.80
Nephtys cornuta franciscanum	ANN	14.00 +/- 14.97	1.06	71.86
Polydora socialis	ANN	14.00 +/- 10.20	1.06	72.92
Orchomene pacifica	ARTH	14.00 +/- 12.00	1.06	73.98
Protomedeia penates/prudens	ARTH	12.00 +/- 7.48	0.91	74.89
Polycirrus sp. complex	ANN	12.00 +/- 11.66	0.91	75.79
Macoma cf. moesta alaskana	MOLL	10.00 +/- 20.00	0.76	76.55
Pentamera sp. Indet.	MISC	10.00 +/- 6.32	0.76	77.31
Spiophanes berkeleyorum	ANN	10.00 +/- 8.94	0.76	78.06
Golfingia minuta	MISC	10.00 +/- 6.32	0.76	78.82
Mya arenaria	MOLL	10.00 +/- 10.95	0.76	79.58
Bivalvia sp. Indet.	MOLL	8.00 +/- 16.00	0.61	80.18
Glycymeris subobsoleta	MOLL	8.00 +/- 4.00	0.61	80.79
Euphilomedes carcharodonta	ARTH	8.00 +/- 11.66	0.61	81.39
Opheliidae sp. Indet.	ANN	8.00 +/- 7.48	0.61	82.00
Rhodine bitorquata	ANN	8.00 +/- 7.48	0.61	82.60
Spiochaetopterus costerum	ANN	8.00 +/- 4.00	0.61	83.21
Sertulariidae sp. Indet.	MISC	8.00 +/- 7.48	0.61	83.81
Nebalia pugettensis	ARTH	8.00 +/- 11.66	0.61	84.42
Proclea graffii	ANN	8.00 +/- 7.48	0.61	85.02
Eudorella pacifica	ARTH	8.00 +/- 7.48	0.61	85.63
Mediomastus sp. Indet.	ANN	6.00 +/- 4.90	0.45	86.08
Leitoscoloplos pugettensis	ANN	6.00 +/- 8.00	0.45	86.54
Chaetozone setosa	ANN	4.00 +/- 8.00	0.30	86.84
Goniada brunnea	ANN	4.00 +/- 8.00	0.30	87.14

TABLE 4-8j. Dominant taxa and community population parameters for station T16-4.

	<del></del>	MEAN N	UMBER		to the property of the second section of the section of
	MAJOR	PER SQUAR	E METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/-1 STANDARI	DEVIATION	TOTAL	PERCENT
Nassarius mendicus	MOLL	4.00 +/-		0.30	87.44
Scoloplos acmeceps	ANN	4.00 +/-		0.30	87.75
Pholoe minuta	ANN	4.00 +/-	4.90	0.30	88.05
Phyllodoce hartmanae	ANN	4.00 +/-	4.90	0.30	88.35
Maldanidae sp. Indet.	ANN	4.00 +/-	4.90	0.30	88.65
Aricidea nr. A. suecica	ANN	4.00 +/-	4.90	0.30	88.96
Cylindroleberidinae sp. Indet.	ARTH	4.00 +/-	4.90	0.30	89.26
Hiatella arctica	MOLL	4.00 +/-	4.90	0.30	89.56
Clymenura colulmbiana	ANN	4.00 +/-	4.90	0.30	89.86
Phyllodoce groenlandica	ANN	4.00 +/-	8.00	0.30	90.17
Remaining taxa	52	130		9.83	
TOTAL =	107 Taxa	1322.00 +/-	206.24		
SIMPSON'S INDEX =		0.060 +/-	0.026		
SHANNON-WIENER INDEX =		3.329 +/-	0.267		
J (EVENESS) =		0.712			

TABLE 4-8k. Dominant taxa and community population parameters for station T22-1.

		MEAN NUMBER		
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/- 1 STANDARD DEVIATION	TOTAL	PERCENT
DOMINANT TAXA	TAXON	+/-131ANDARD DEVIATION	TOTAL	TERCENT
Prionospio steenstrupi	ANN	1840.00 +/- 628.55	14.51	14.51
Euphilomedes carcharodonta	ARTH	1634.00 +/- 1196.14	12.88	27.39
Armandia brevis	ANN	1190.00 +/- 431.65	9.38	36.78
Prionospio lighti	ANN	780.00 +/- 356.48	6.15	42.93
Lumbrineris sp. Indet.	ANN	542.00 +/- 116.00	4.27	47.20
Exogone lourei	ANN	434.00 +/- 161.94	3.42	50.62
Mediomastus californiensis	ANN	392.00 +/- 187.34	3.09	53.71
Spiochaetopterus costerum	ANN	382.00 +/- 98.67	3.01	56.73
Eudorella pacifica	ARTH	336.00 +/- 117.23	2.65	59.38
Kefersteinia cirrata	ANN	254.00 +/- 119.60	2.00	61.38
Oligochaeta sp. Indet.	ANN	216.00 +/- 142.07	1.70	63.08
Metaphoxus fultoni	ARTH	212.00 +/- 63.69	1.67	64.75
Protodorvillea gracilis	ANN	188.00 +/- 122.54	1.48	66.24
Macoma carlottensis	MOLL	176.00 +/- 88.23	1.39	67.62
Leptochelia savignyi	ARTH	•	1.32	68.95
Eumida sanguinea		•	1.31	70.26
Syllis heterochaeta	ANN ANN	•	1.10	70.26 71.36
Notomastus tenuis		•	0.88	72.24
	ANN	•	0.87	73.11
Laonice pugettensis	ANN	110.00 +/- 35.21		73.95
Chaetozone sp. 1	ANN	106.00 +/- 58.86	0.84	73.93 74.77
Glycera capitata Platynereis bicanaliculata	ANN	104.00 +/- 33.82	0.82	7 <b>5.</b> 59
•	ANN	104.00 +/- 65.30	0.82 0.76	75.39 76.34
Euphilomedes producta Polydora socialis	ARTH	96.00 +/- 40.30		70.34 77.09
	ANN	94.00 +/- 69.46	0.74	77.80
Cancer sp. Indet. (larvae & juvenile) Caulleriella hamata	ARTH	90.00 +/- 36.88	0.71	
· · · · · · · · · · · · · · · · · · ·	ANN	88.00 +/- 37.63	0.69	78.49
Heterophoxus oculatus	ARTH	80.00 +/- 26.08	0.63	79.12
Pandora filosa	MOLL	80.00 +/- 22.80	0.63	79.75
Dexamonica reduncans	ARTH	76.00 +/- 34.41	0.60	80.35
Lophopanopeus bellus (larvae & adult)	ARTH	74.00 +/- 26.53	0.58	80.93
Amphiporus sp. Indet.	MISC	70.00 +/- 46.90	0.55	81.49
Tharyx multifilis	ANN	68.00 +/- 16.00	0.54	82.02
Balanus sp. Indet. (juvenile)	ARTH	64.00 +/- 48.00	0.50	82.53
Eulalia levicornuta	ANN	62.00 +/- 52.31	0.49	83.02
Cirratulus cirratus	ANN	62.00 +/- 29.93	0.49	83.50
Phyllodoce hartmanae	ANN	60.00 +/- 26.08	0.47	83.98
Aeolidacea sp. Indet.	MOLL	60.00 +/- 38.47	0.47	84.45
Balanus crenatus	ARTH	58.00 +/- 27.86	0.46	84.91
Mysella tumida	MOLL	56.00 +/- 23.32	0.44	85.35
Nephtys ferruginea	ANN	52.00 +/- 38.68	0.41	85.76
Plumulariidae sp. Indet.	MISC	50.00 +/- 67.53	0.39	86.15
Gyptis brevipalpa	ANN	50.00 +/- 29.66	0.39	86.55
Nematoda sp. Indet.	MISC	50.00 +/- 20.00	0.39	86.94
Nereis procera	ANN	48.00 +/- 22.27	0.38	87.32
Astarte alaskensis	MOLL	46.00 +/- 34.41	0.36	87.68

TABLE 4-8k. Dominant taxa and community population parameters for station T22-1.

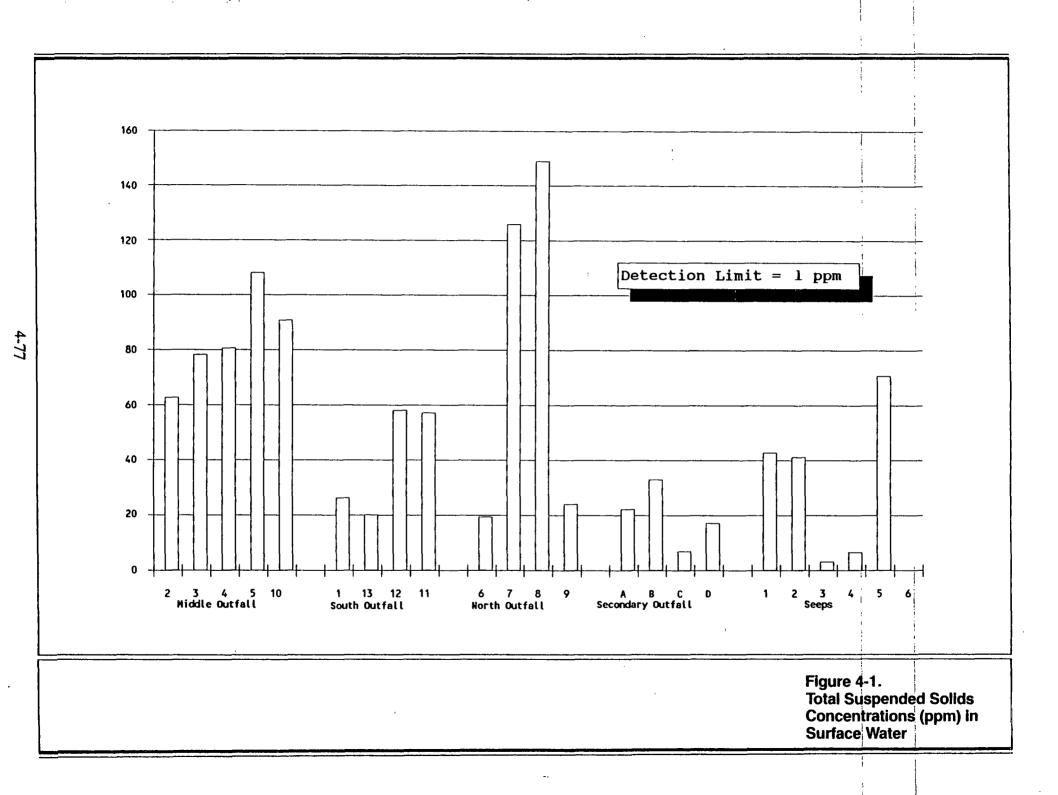
		MEA	N N	JMBER		
	MAJOR	PER SQUA	ARE	METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/- 1 STANDA	RD	DEVIATION	TOTAL	PERCENT
Polydora pygidialis	ANN	46.00	+/-	24.17	0.36	88.05
Eteone californica	ANN	46.00	+/-	41.28	0.36	88.41
Syllis elongata	ANN	46.00	+/-	36.66	0.36	88. <i>7</i> 7
Melita desdichada	ARTH	44.00	+/-	16.25	0.35	89.12
Hesionidae sp. Indet.	ANN	44.00	+/-	37.20	0.35	89.47
Diastylis sp. B	ARTH	42.00	+/-	19.39	0.33	89.80
Pectinaria sp. Juv	ANN	42.00	+/-	17.20	0.33	90.13
Remaining taxa	142	1252			9.87	
TOTAL =	194 Taxa	12682.00	+/-	3004.10		
SIMPSON'S INDEX =		0.065	+/-	0.021		
SHANNON-WIENER INDEX =		3.512	+/-	0.205		
J (EVENESS) =		0.667				

TABLE 4-8l. Dominant taxa and community population parameters for station T22-2.

		MEAN NUMBER		<u> </u>
-	MATOR		PERCENT OF	CUMULATIVE
DOMESTA NEW TOWN	MAJOR	PER SQUARE METER	TOTAL	PERCENT '
DOMINANT TAXA	TAXON	+/- 1 STANDARD DEVIATION	TOTAL	FERCEIVI
Euskilomodos soroborodosto	ARTH	1834.00 +/- 579.85	18.37	18.37
Euphilomedes carcharodonta Prionospio steenstrupi	ANN	1088.00 +/- 371.13	10.90	29.27
Prionospio lighti	ANN	692.00 +/- 410.58	6.93	36.21
Euphilomedes producta	ARTH	618.00 +/- 225.69	6.19	42.40
Lumbrineris sp. Indet.	ANN	326.00 +/- 25.77	3.27	45.66
Mediomastus californiensis	ANN	290.00 +/- 103.54	2.91	48.57
Pholoides aspera	ANN	286.00 +/- 108.74	2.87	51.43
Eudorella pacifica	ARTH	280.00 +/- 107.33	2.81	54.24
Cerebratulus sp. 1.	MISC	258.00 +/- 106.28	2.58	56.82
Tharyx multifilis	ANN	222.00 +/- 100.68	2.22	59.05
•		210.00 +/- 420.00	2.10	61.15
Balanus sp. Indet. (juvenile)	ARTH	•	2.00	63.15
Exogone lourei	ANN	•	1.84	65.00
Leptochelia savignyi	ARTH	184.00 +/- 40.30	1.82	66.82
Pinnixa cf. schmitti	ARTH	182.00 +/- 129.98	1.62	68.44
Pectinaria californiensis	ANN	162.00 +/- 65.54		69.87
Modiolus rectus	MOLL	142.00 +/- 47.92	1.42	71.23
Metaphoxus fultoni	ARTH	136.00 +/- 69.46	1.36	71.23 72.49
Polydora socialis	ANN	126.00 +/- 88.23	1.26	
Kefersteinia cirrata	ANN	116.00 +/- 43.63	1.16	73.65
Cardiomya californica	MOLL	108.00 +/- 83.52	1.08	74.73
Glycera capitata	ANN	100.00 +/- 26.08	1.00	75.74
Alia gausapata	MOLL	74.00 +/- 65.60	0.74	76.48
Lucinoma acutilineata	MOLL	74.00 +/- 41.28	0.74	77.22
Cirratulus cirratus	ANN	74.00 +/- 12.00	0.74	77.96
Nicomache personata	ANN	70.00 +/- 70.14	0.70	78.66
Spiochaetopterus costerum	ANN	70.00 +/- 37.42	0.70	79.36
Syllis heterochaeta	ANN	70.00 +/- 45.17	0.70	80.06
Nereis wailesi	ANN	66.00 +/- 34.99	0.66	80.73
Heterophoxus oculatus	ARTH	64.00 +/- 20.59	0.64	81.37
Velutina velutina	MOLL	62.00 +/- 24.82	0.62	81.99
Polydora brachycephala	ANN	62.00 +/- 71.67	0.62	82.61
Pectinaria sp. Juv	ANN	58.00 +/- 59.46	0.58	83.19
Spiophanes berkeleyorum	ANN	58.00 +/- 43.08	0.58	83.77
Oligochaeta sp. Indet.	ANN	56.00 +/- 38.78	0.56	84.33
Notomastus tenuis	ANN	52.00 +/- 45.34	0.52	84.85
Opheliidae sp. Indet.	ANN	50.00 +/- 52.92	0.50	85.35
Cucumaria sp. 1 Indet.	MISC	48.00 +/- 27.86	0.48	85.83
Diopatra ornata	ANN	46.00 +/- 32.00	0.46	86.30
Caulleriella hamata	ANN	42.00 +/- 25.61	0.42	86.72
Dorvillea japonica	ANN	42.00 +/- 50.75	0.42	87.14
Armandia brevis	ANN	42.00 +/- 24.82	0.42	87.56
Polynoidae sp. Indet.	ANN	36.00 +/- 29.39	0.36	87.92
Protodorvillea gracilis	ANN	40.00 +/- 24.49	0.40	88.32
Eulalia bilineata	ANN	40.00 +/- 0.00	0.40	88.72
Laonice pugettensis	ANN	34.00 +/- 18.55	0.34	89.06

TABLE 4-81. Dominant taxa and community population parameters for station T22-2.

		MEAN NUMBER		
	MAJOR	PER SQUARE METER	PERCENT OF	CUMULATIVE
DOMINANT TAXA	TAXON	+/- 1 STANDARD DEVIATIO	N TOTAL	PERCENT
Eumida sanguinea	ANN	32.00 +/- 13.27	0.32	89.38
Amphicteis glabra	ANN	30.00 +/- 10.95	0.30	89.68
Bowerbankia gracilis	MISC	30.00 +/- 20.00	0.30	89.98
Polydora sp. Indet.	ANN	28.00 +/- 16.00	0.28	90.26
Remaining taxa	135	972	9.74	
TOTAL =	184 Taxa	9982.00 +/- 1917.59		
SIMPSON'S INDEX =		0.068 +/- 0.011		
SHANNON-WIENER INDEX =		3.448 +/- 0.081		
J (EVENESS) =		0.661		



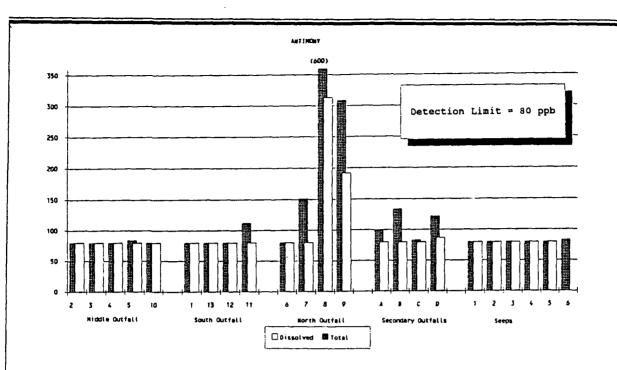
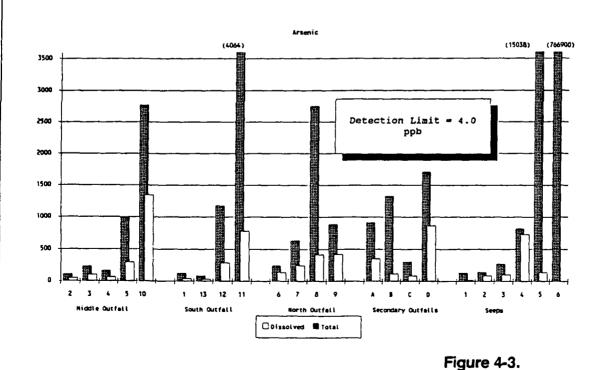


Figure 4-2.
Antimony Concentrations (ppb) in Surface Water

**Arsenic Concentrations (ppb)** 

in Surface Water



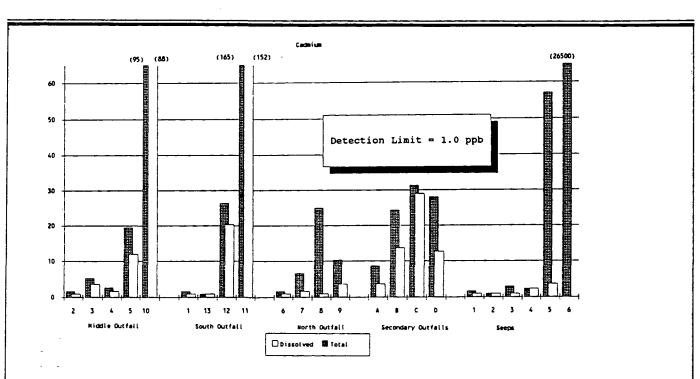
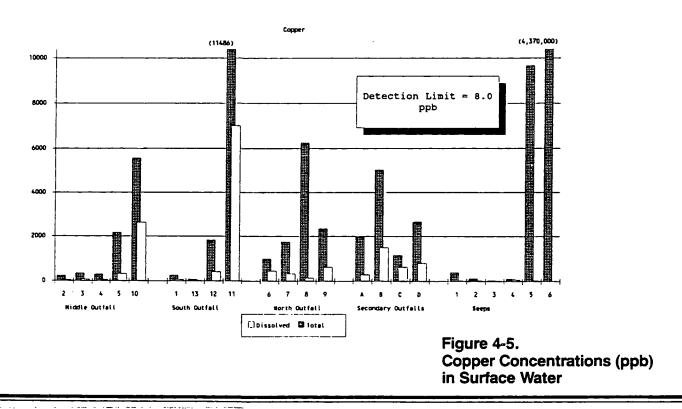


Figure 4-4.
Cadmium Concentrations (ppb) in Surface Water



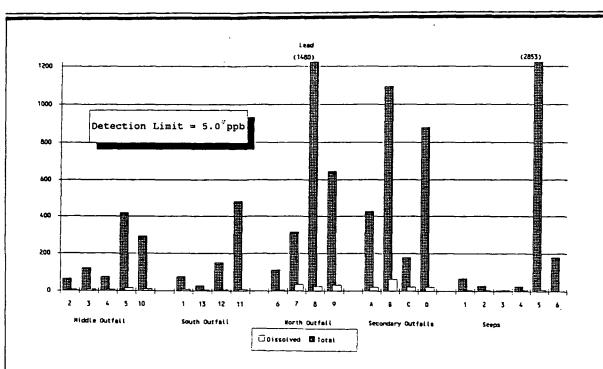


Figure 4-6. Lead Concentrations (ppb) in Surface Water

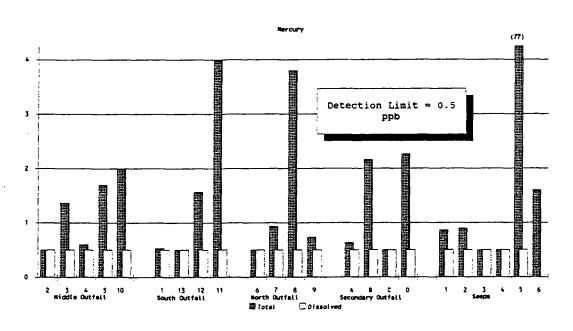


Figure 4-7.
Mercury Concentrations (ppb)
in Surface Water

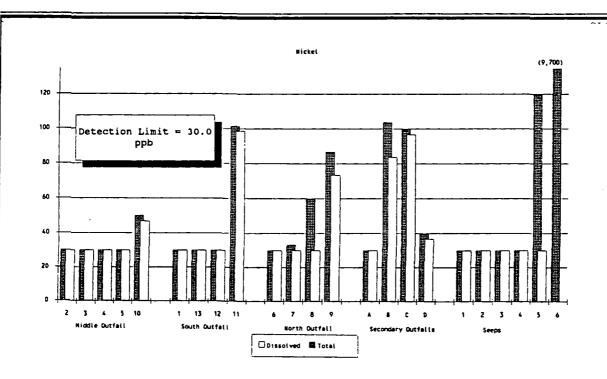


Figure 4-8.
Nickel Concentrations (ppb) in Surface Water

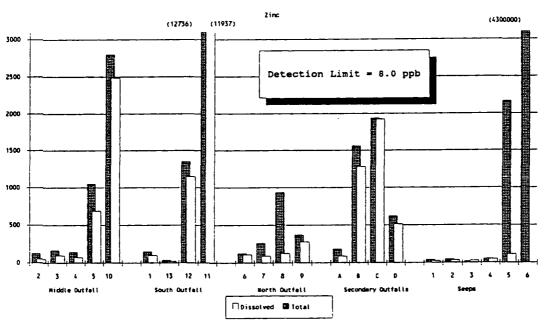
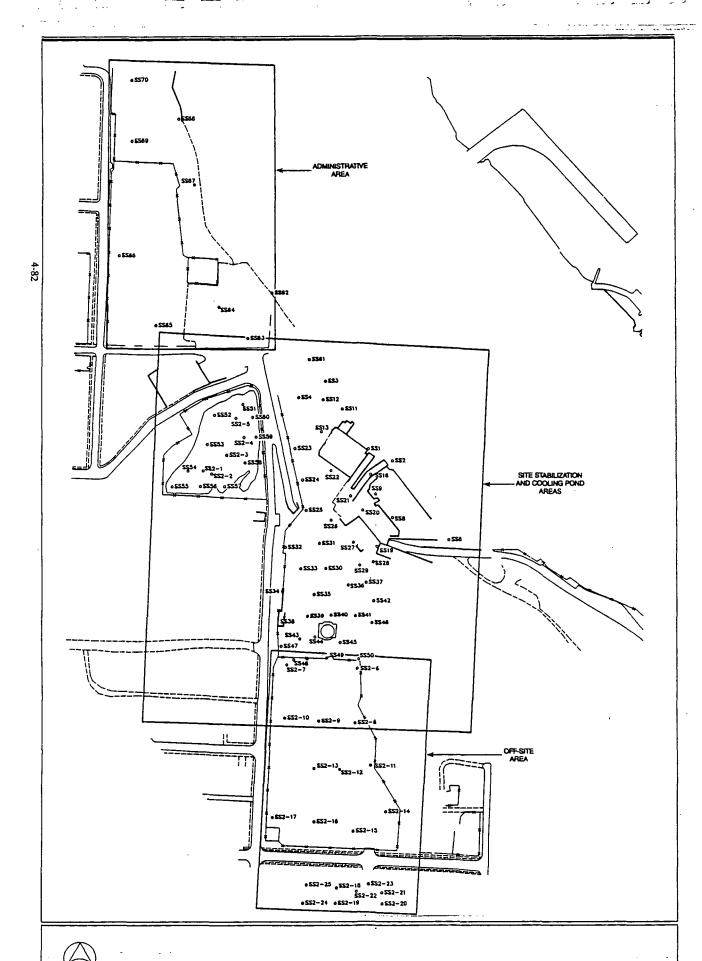
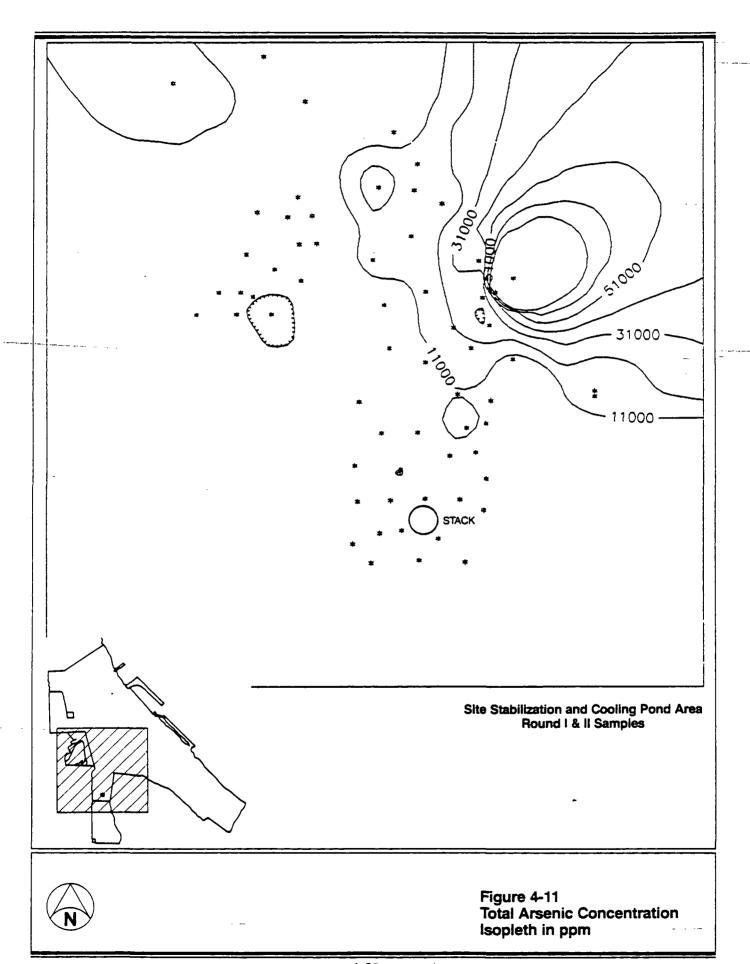
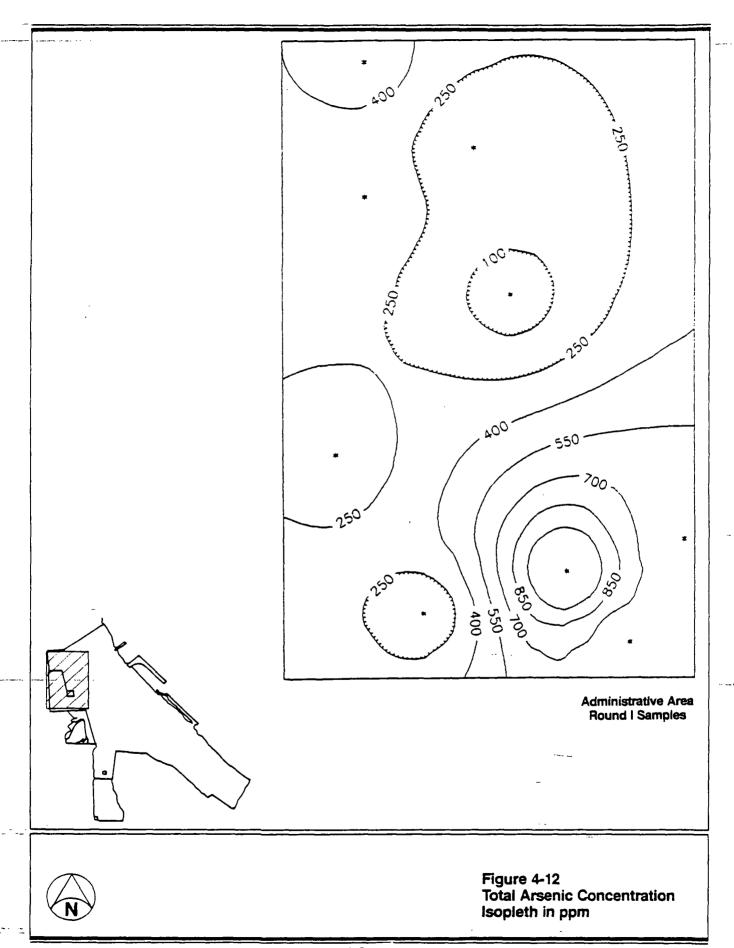


Figure 4-9.
Zinc Concentrations (ppb) in Surface Water







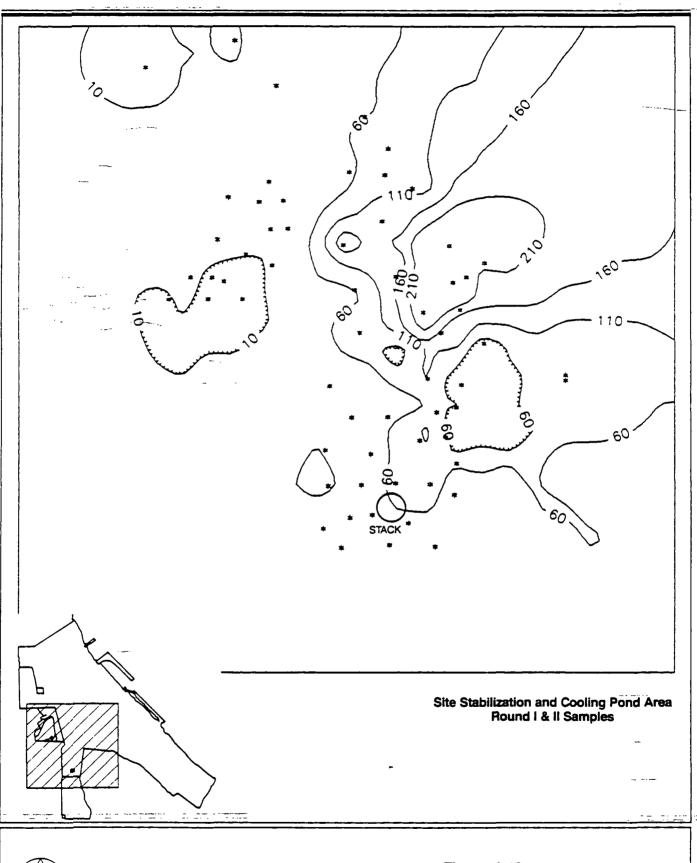
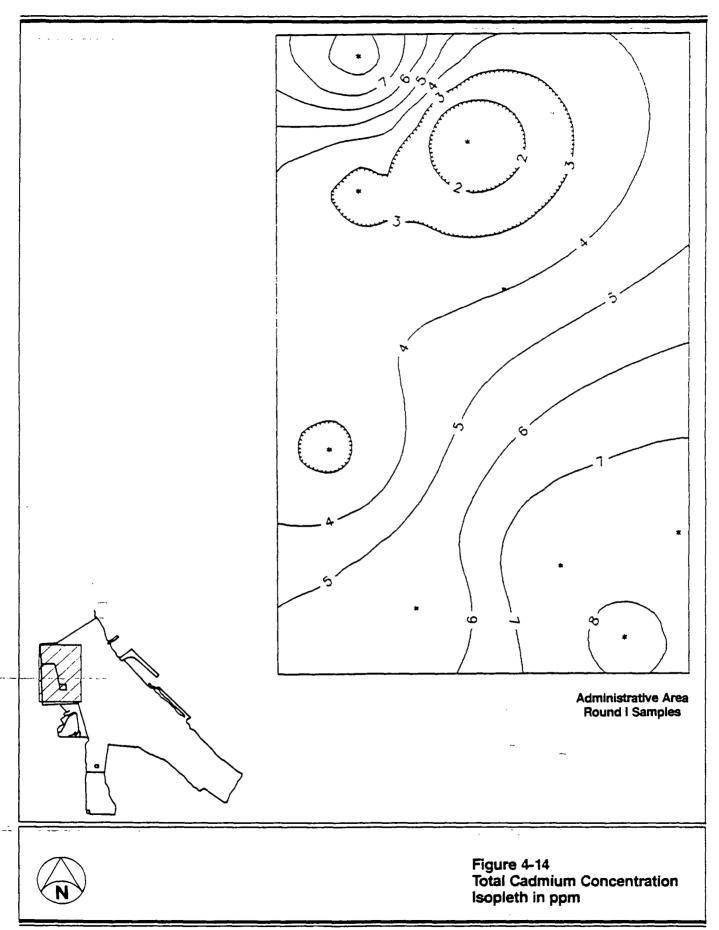
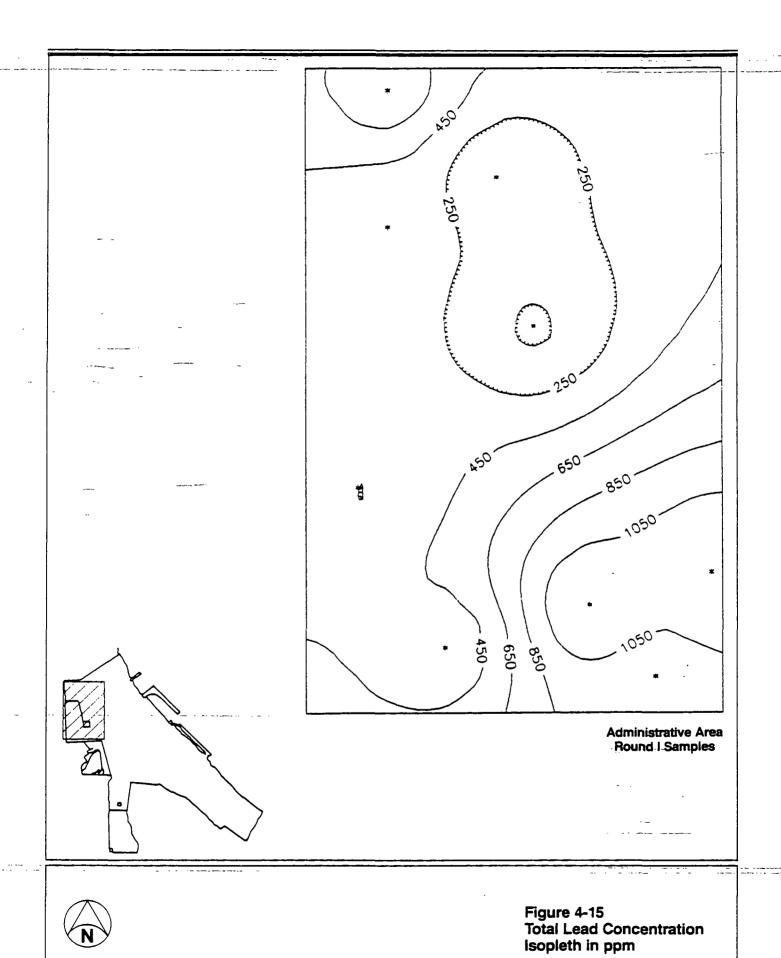


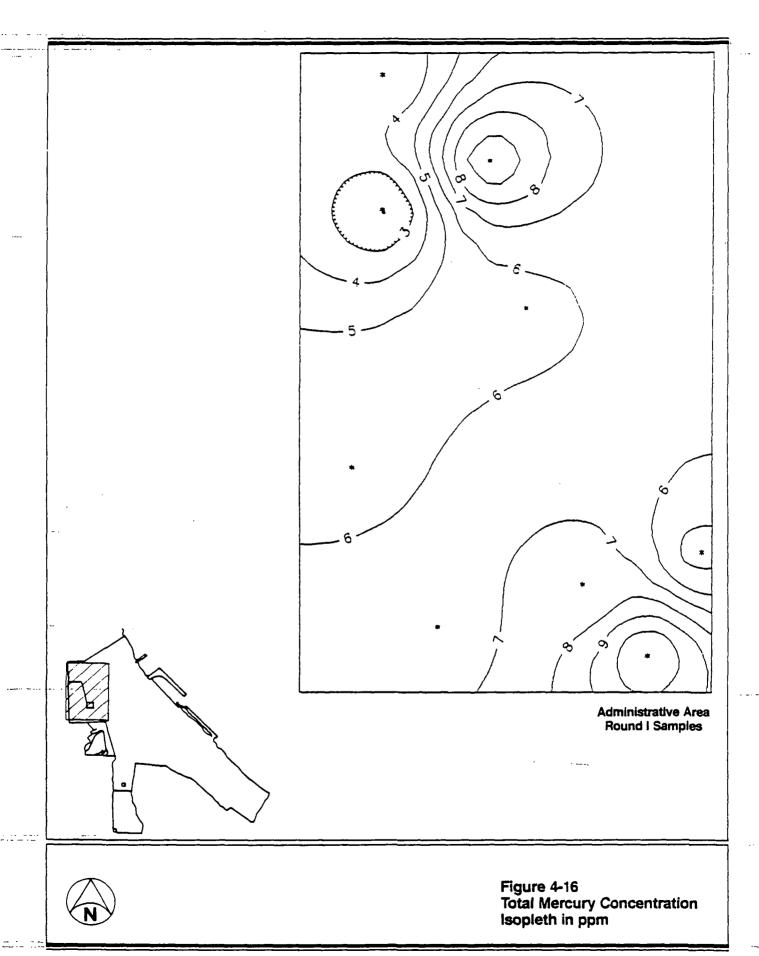


Figure 4-13 Total Cadmium Concentration Isopleth in ppm





4-87



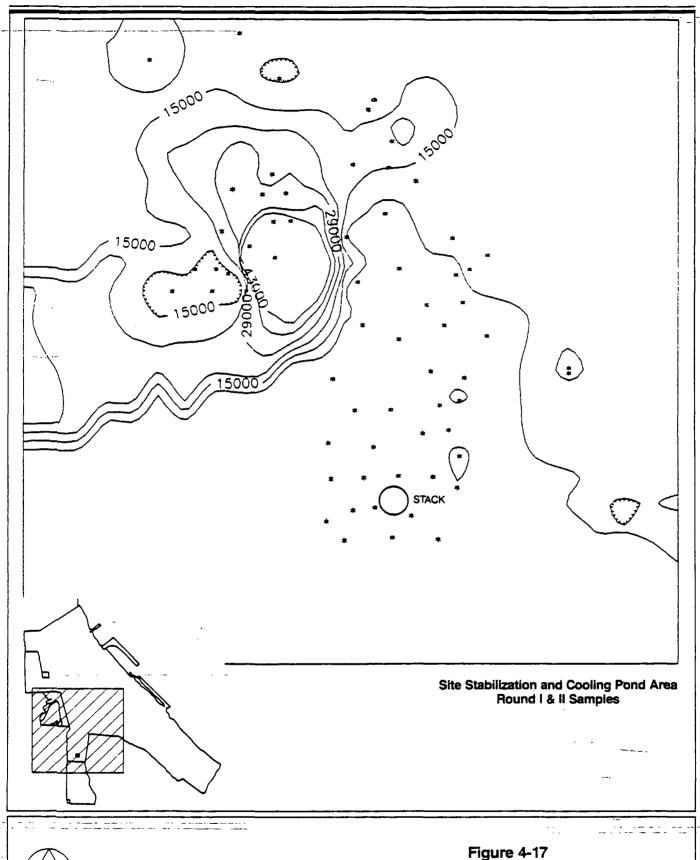
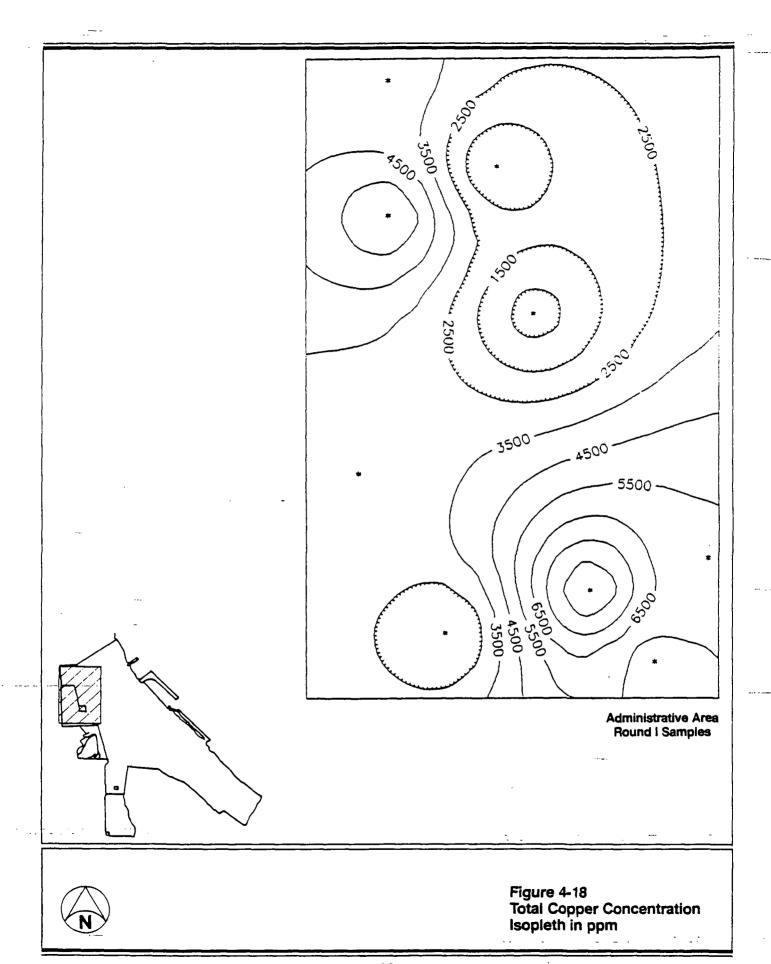
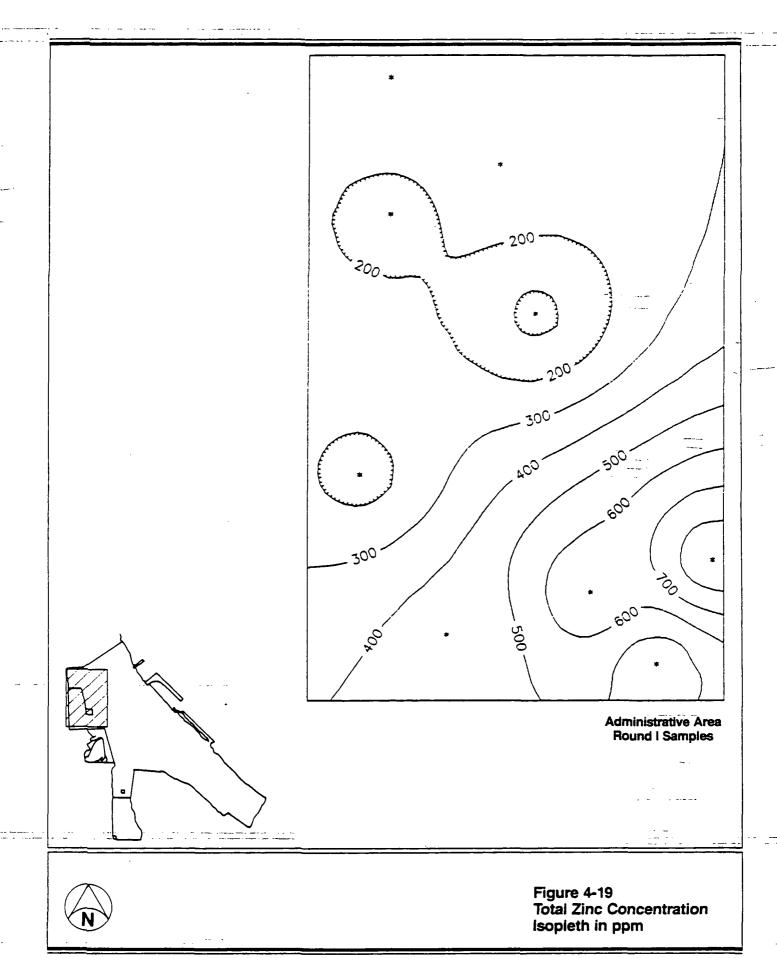
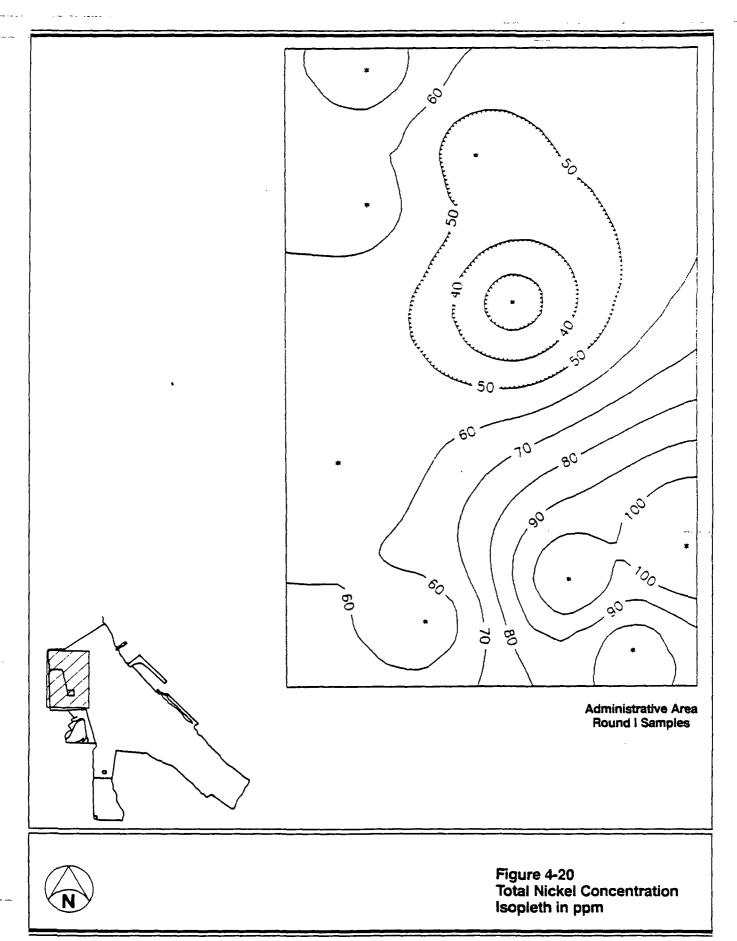


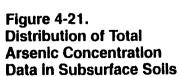


Figure 4-17 Total Copper Concentration Isopleth in ppm









**Native Soil** 

Slag Fill



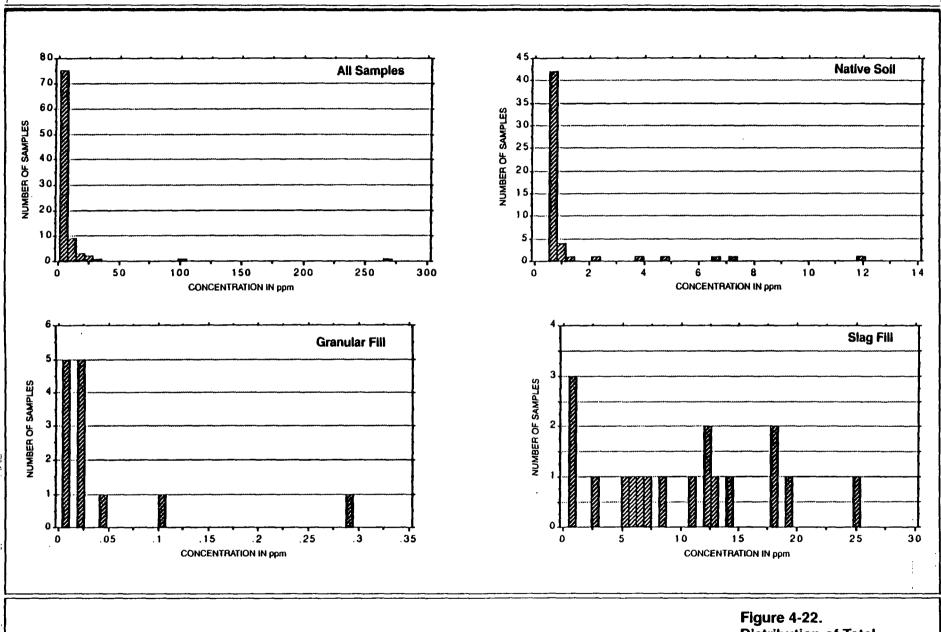
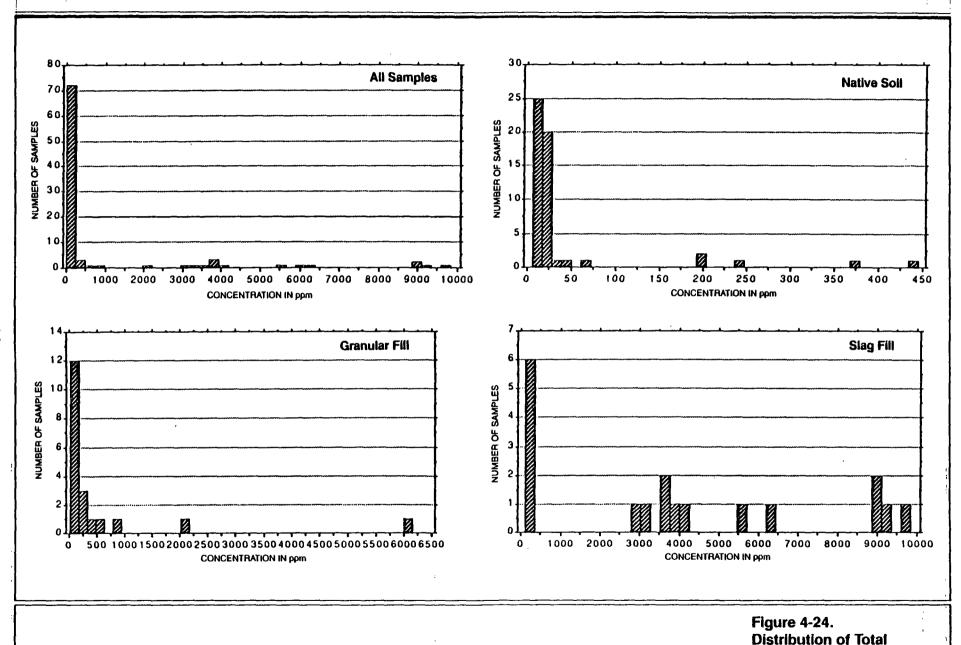


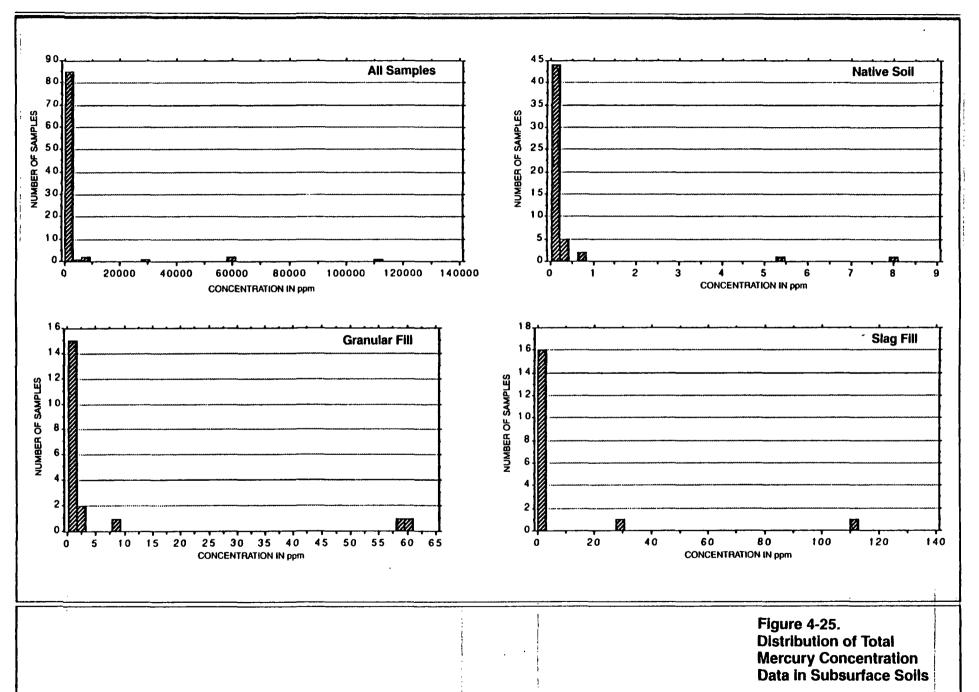
Figure 4-22.
Distribution of Total
Cadmium Concentration
Data in Subsurface Soils

Figure 4-23.
Distribution of Total
Copper Concentration
Data in Subsurface Soils





Lead Concentration
Data in Subsurface Soils



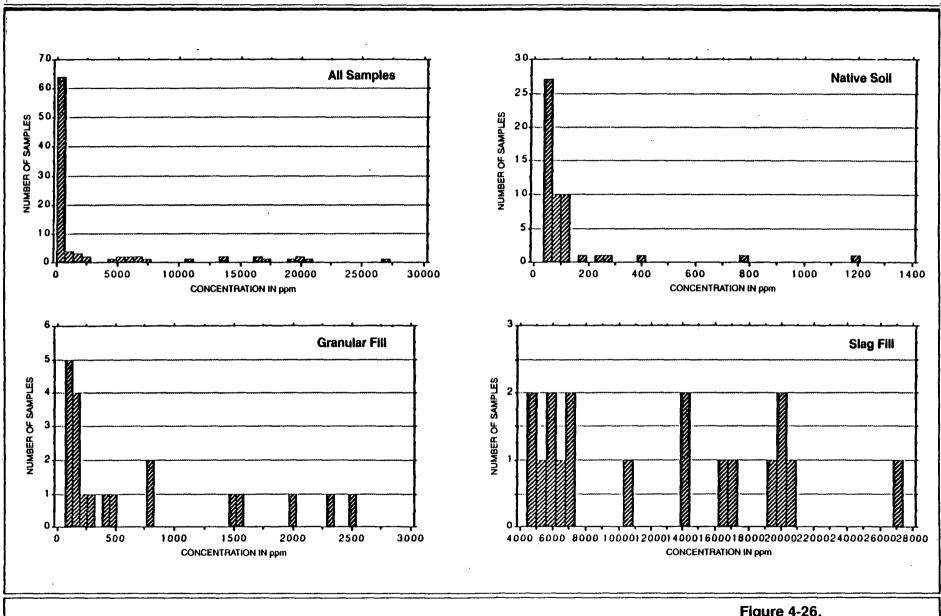


Figure 4-26.
Distribution of Total
Zinc Concentration
Data in Subsurface Soils

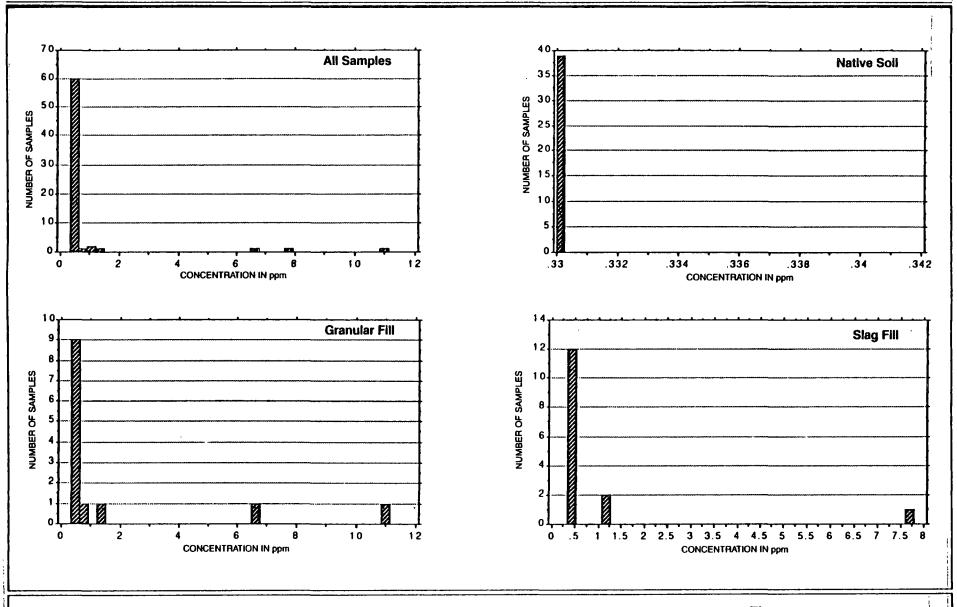
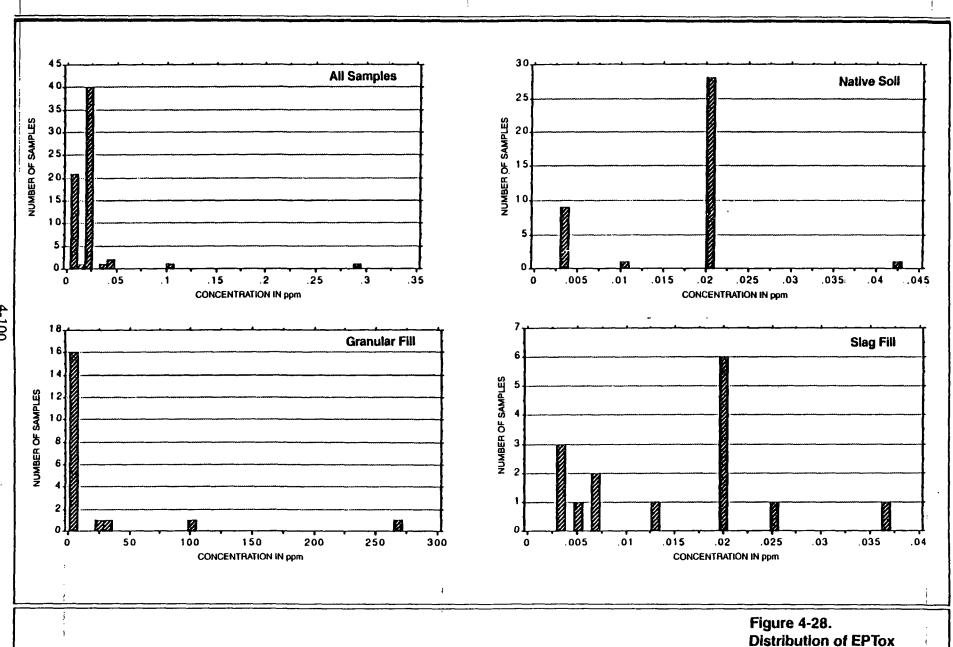
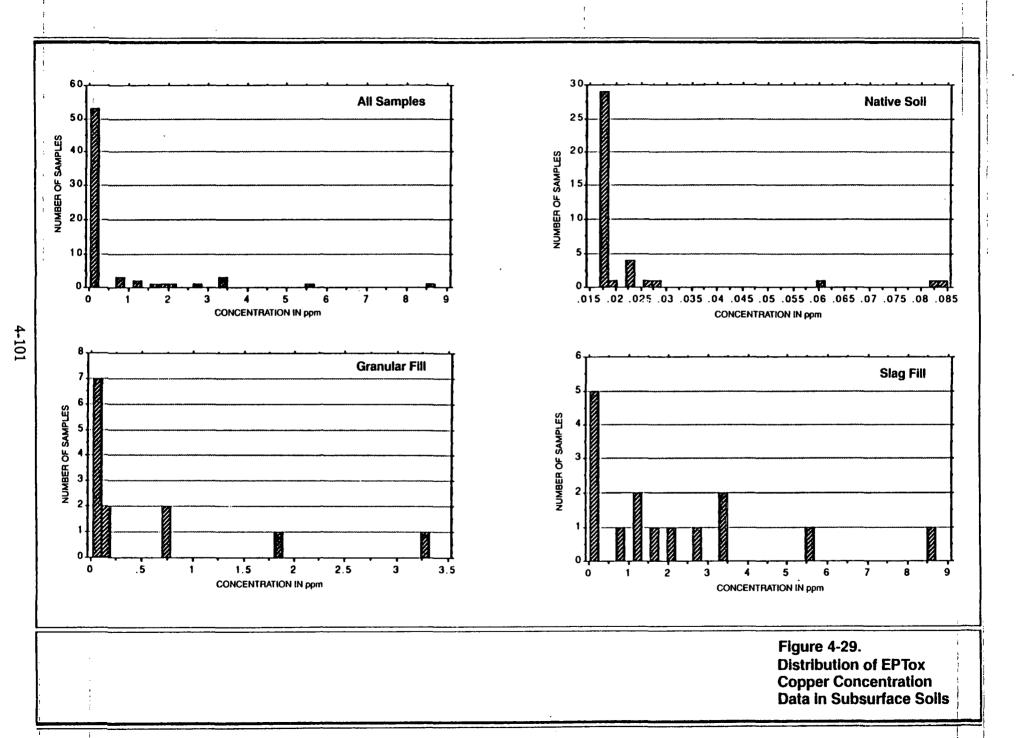
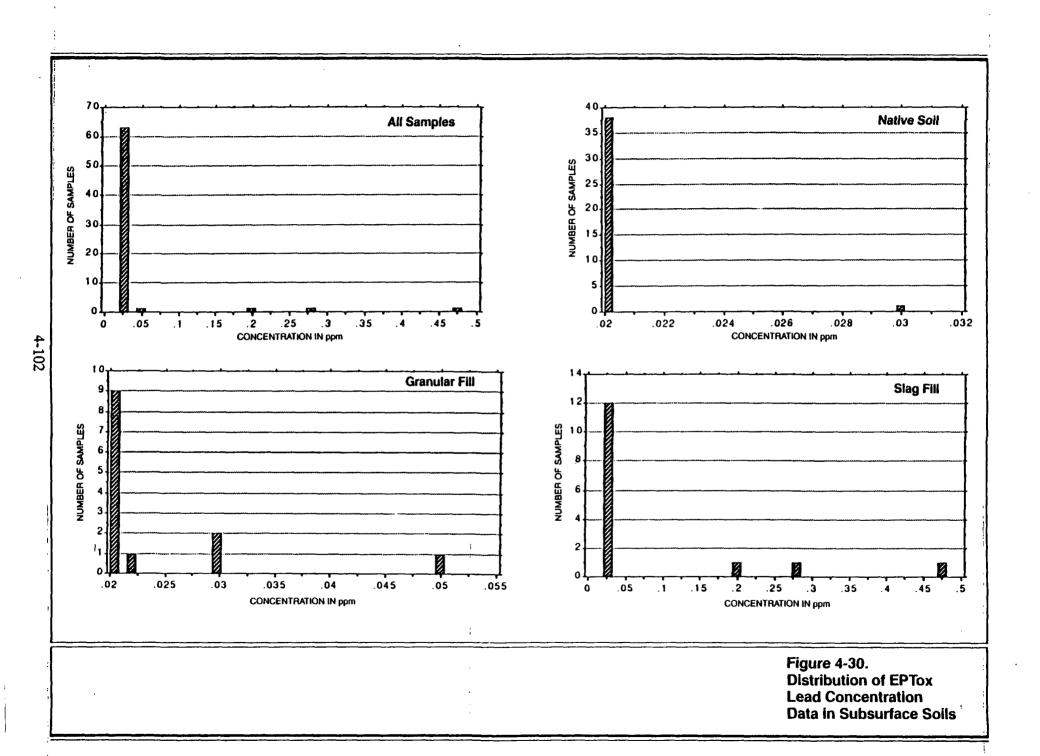


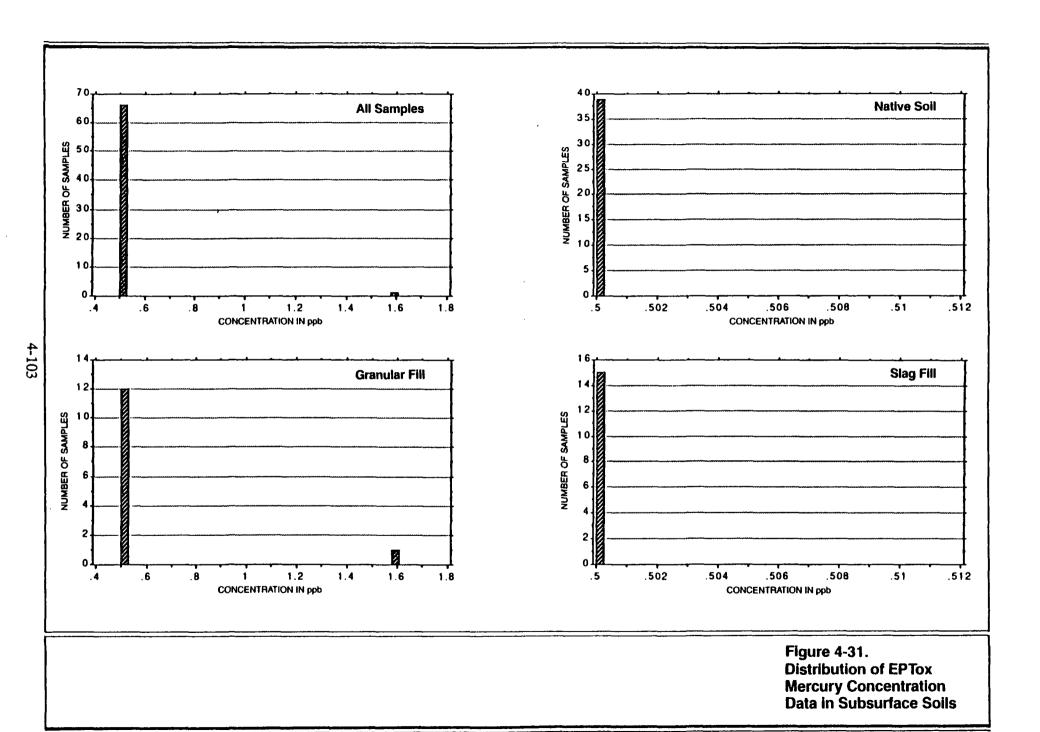
Figure 4-27.
Distribution of EPTox
Arsenic Concentration
Data in Subsurface Soils

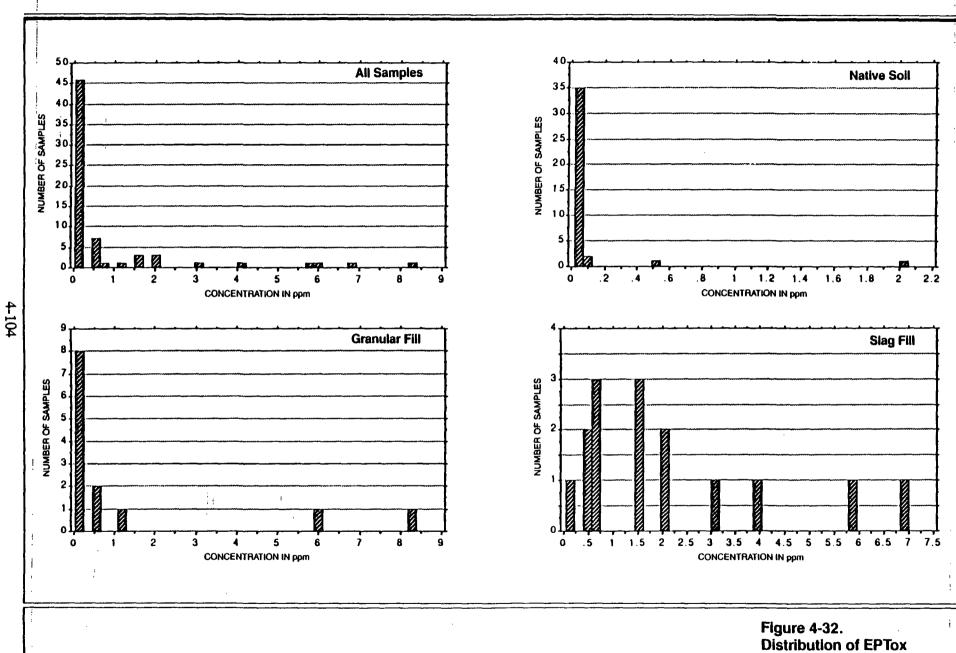


**Cadmium Concentration Data in Subsurface Soils** 

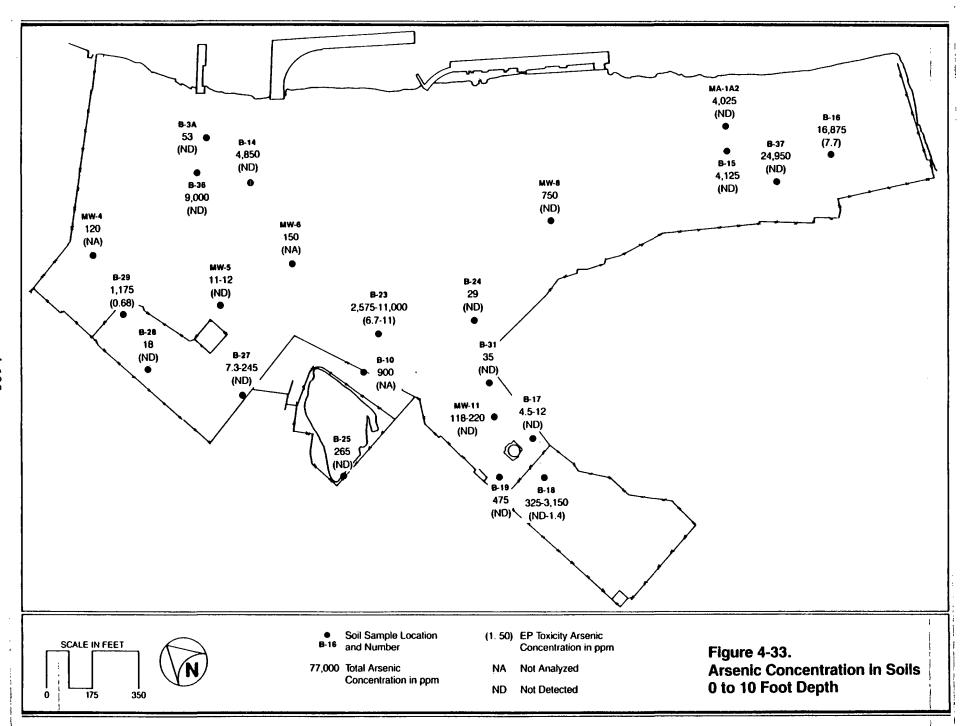


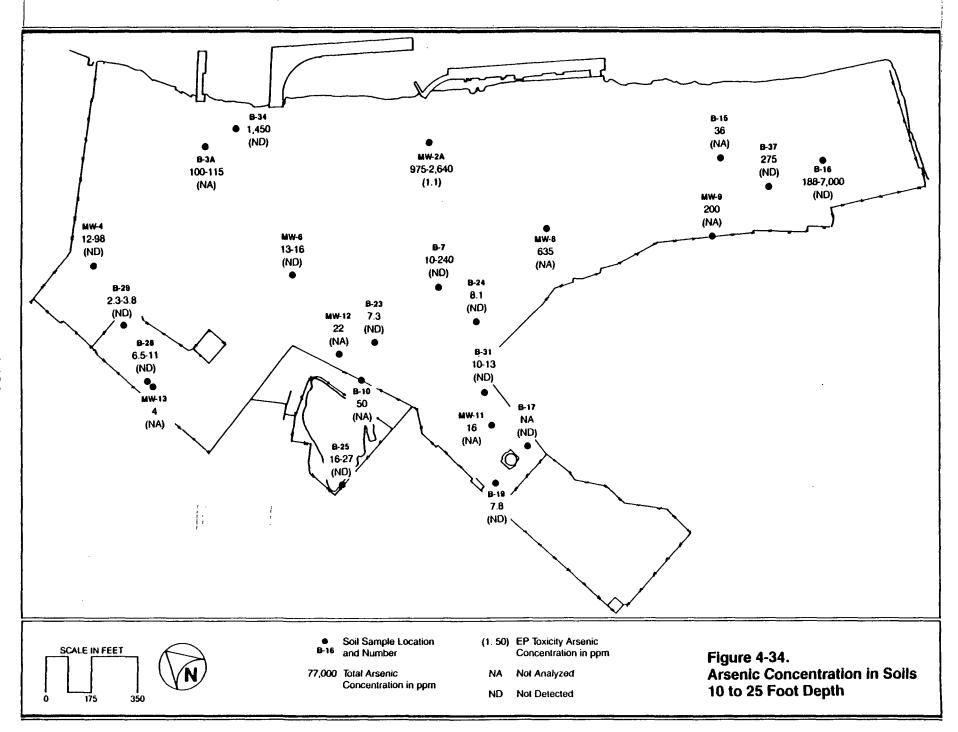


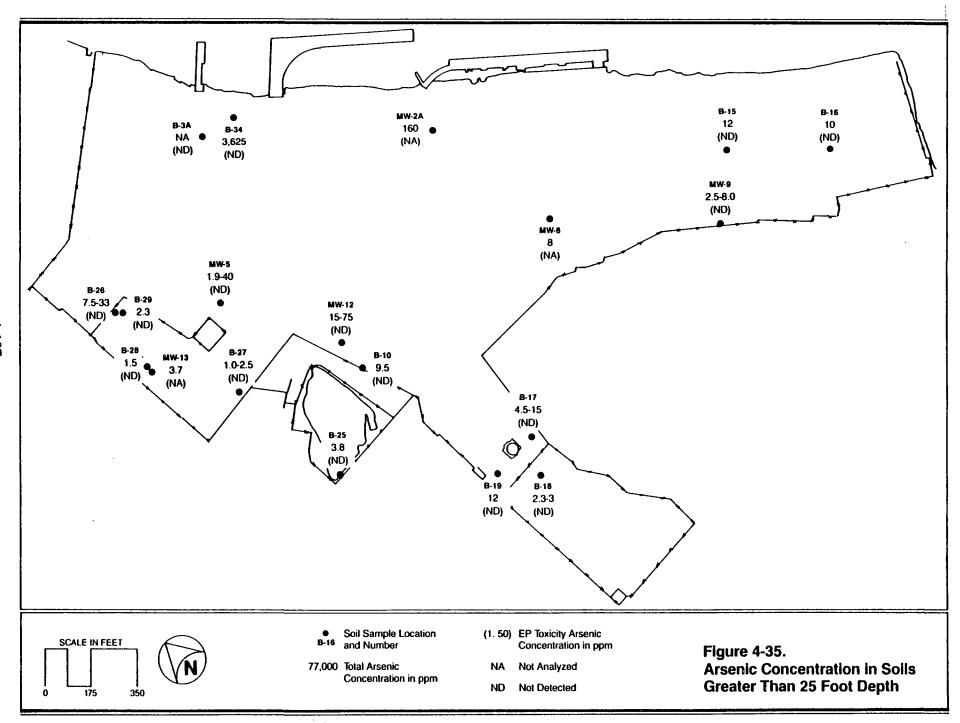


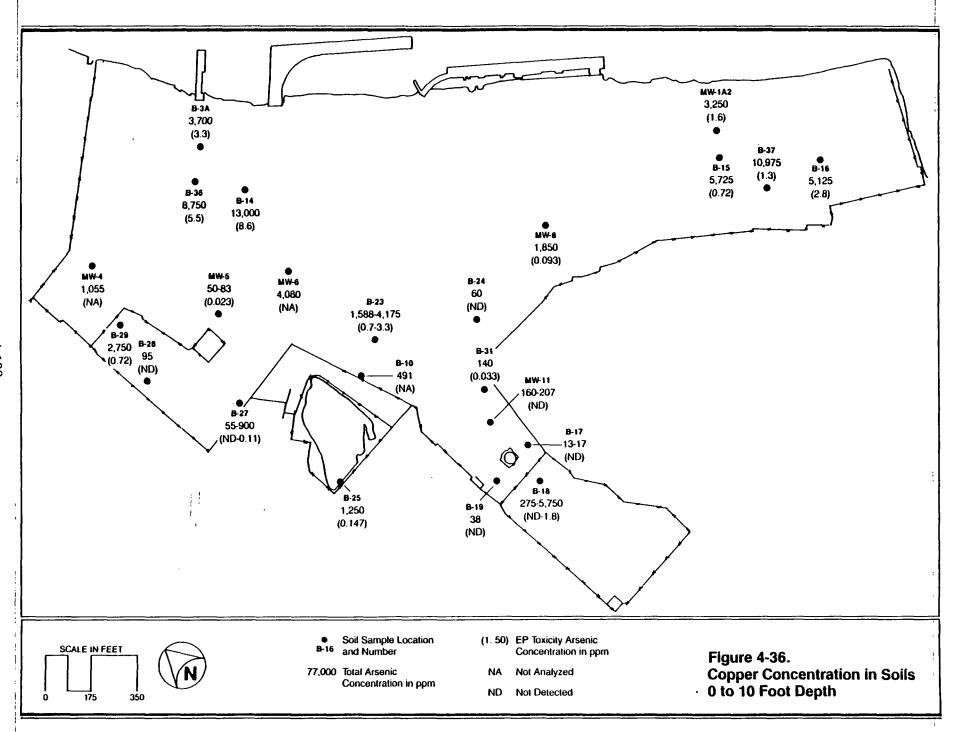


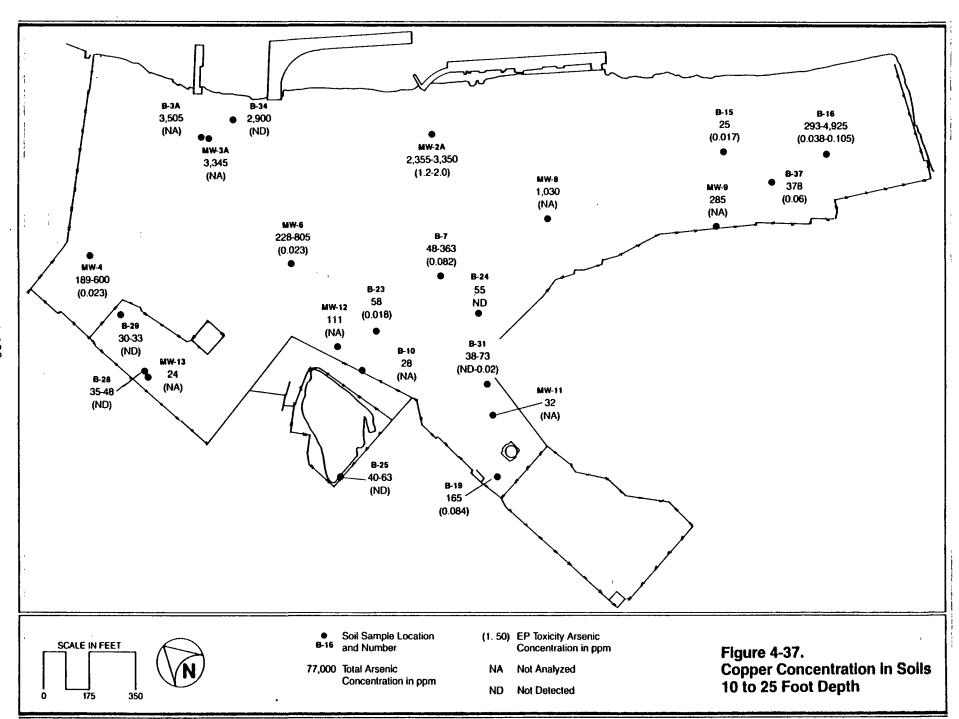
**Zinc Concentration Data in Subsurface Soils** 

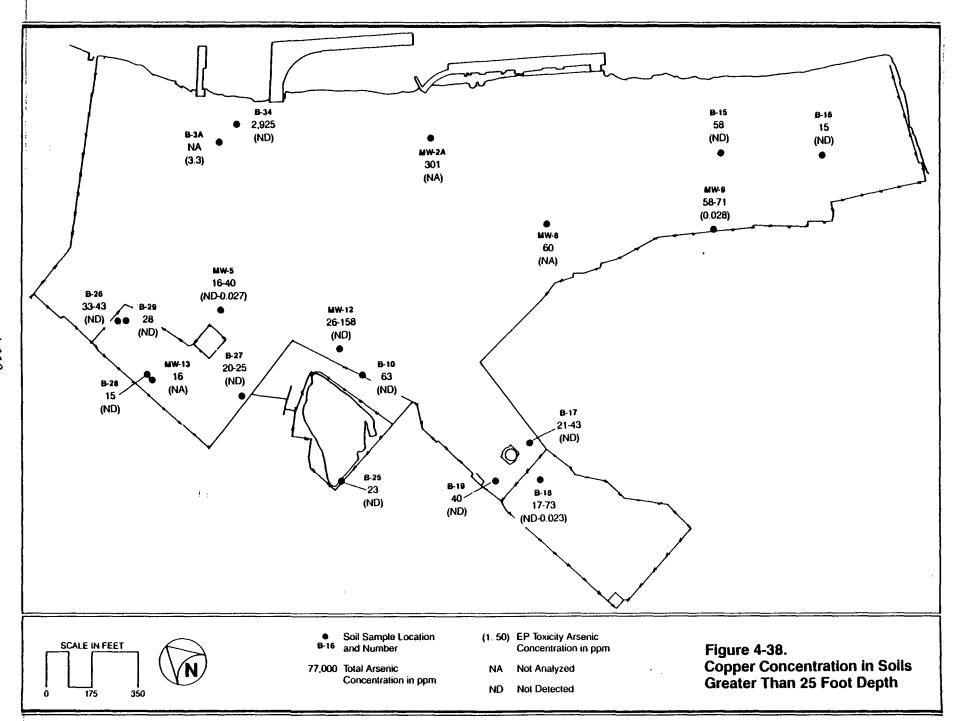


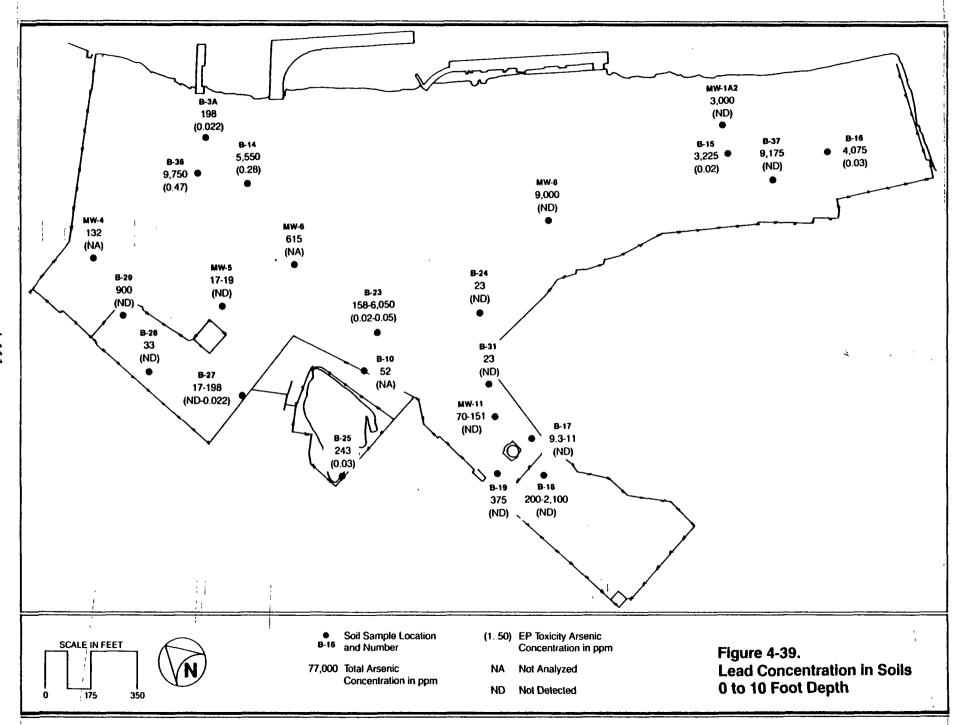


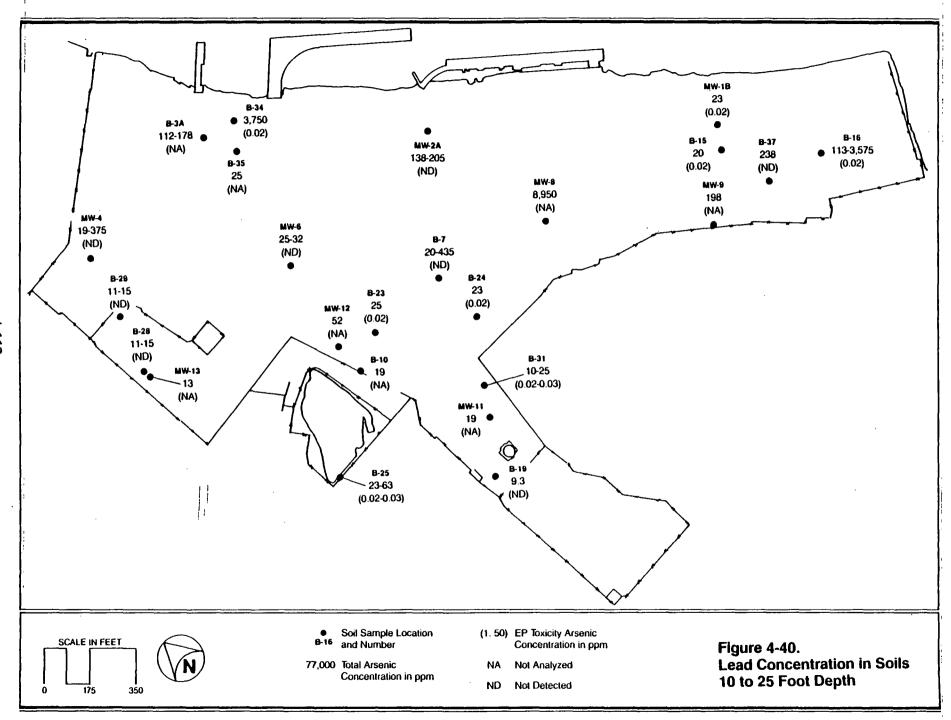


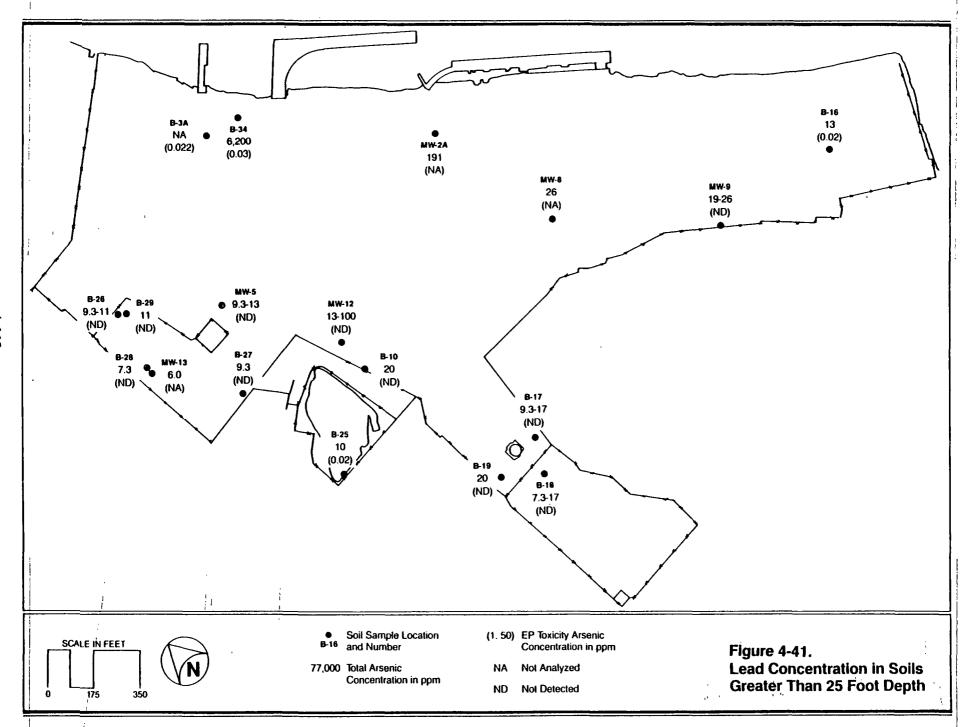


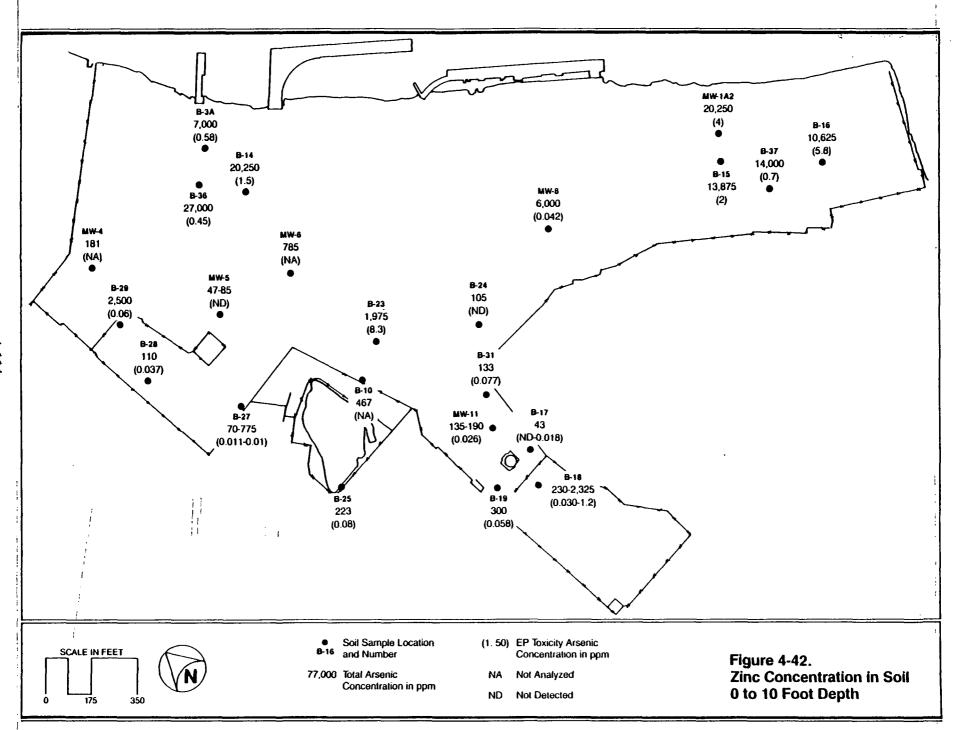


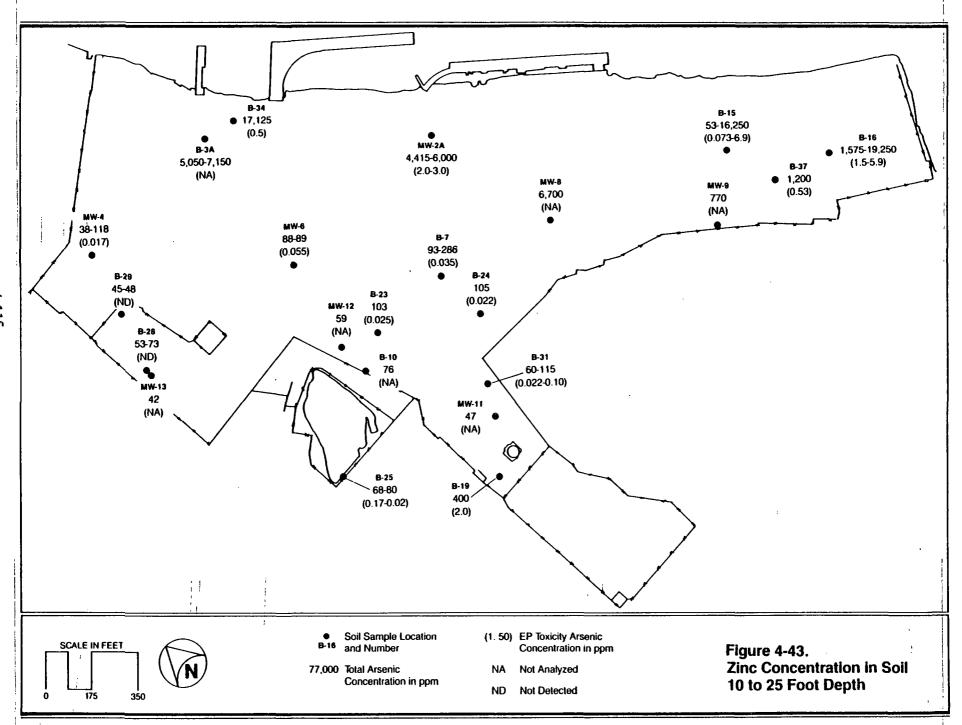


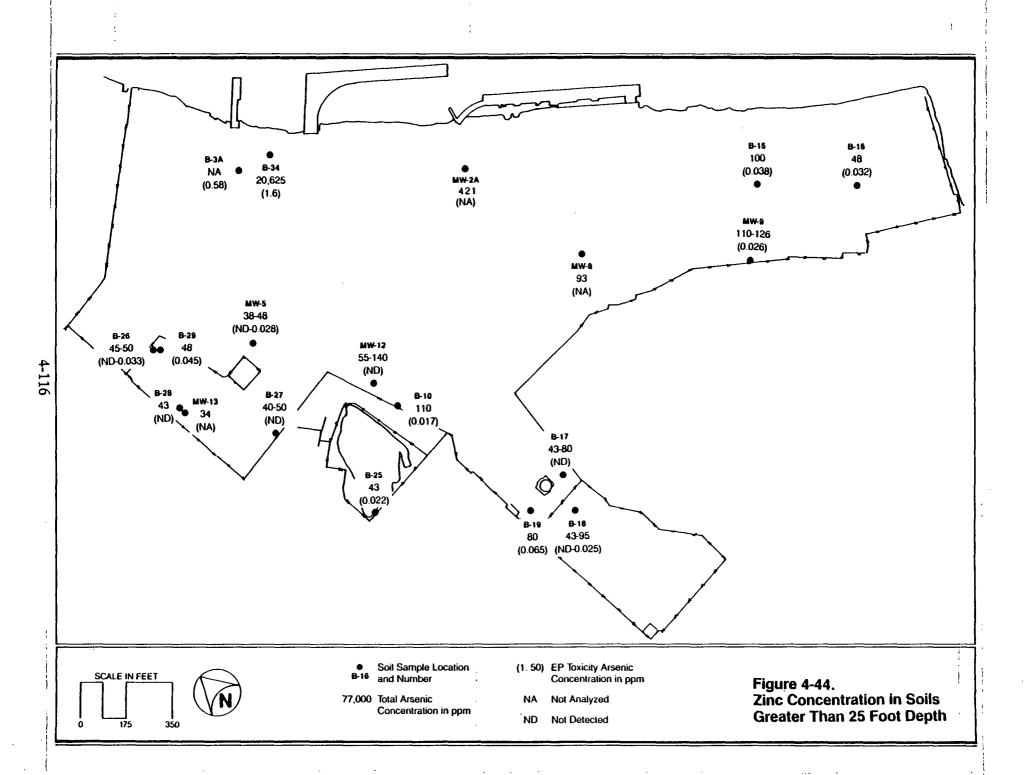


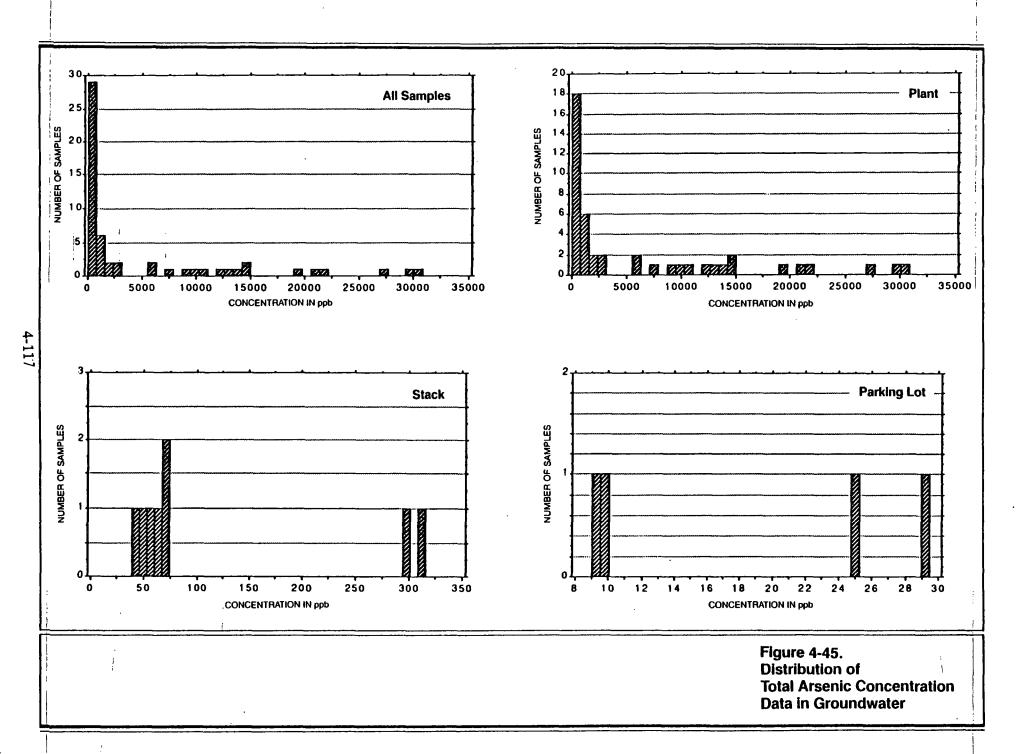


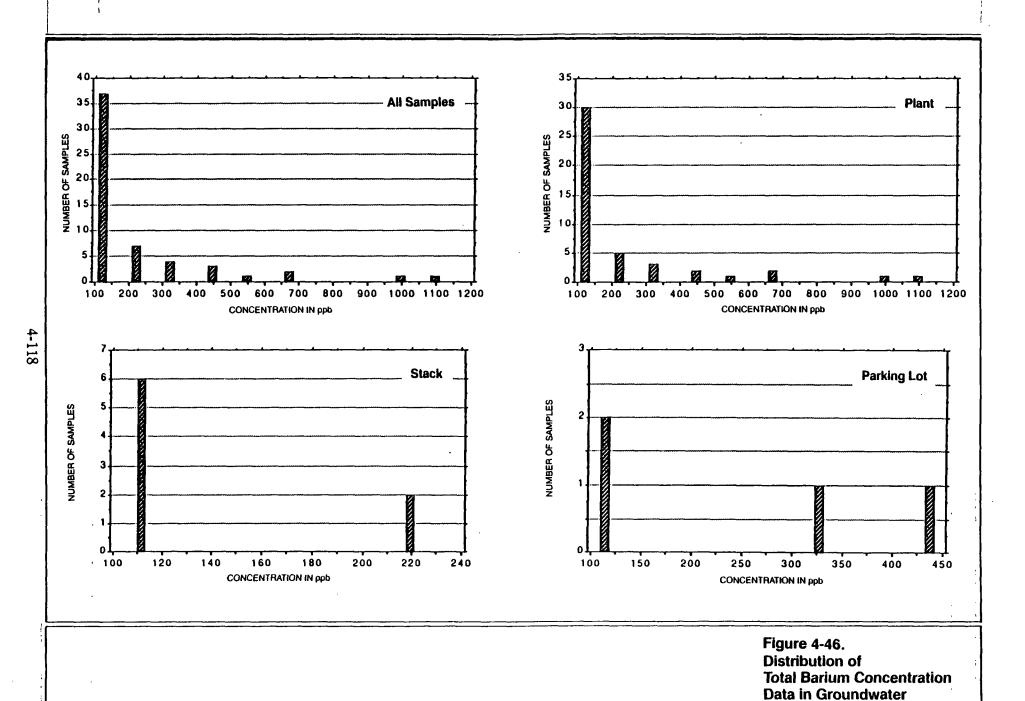


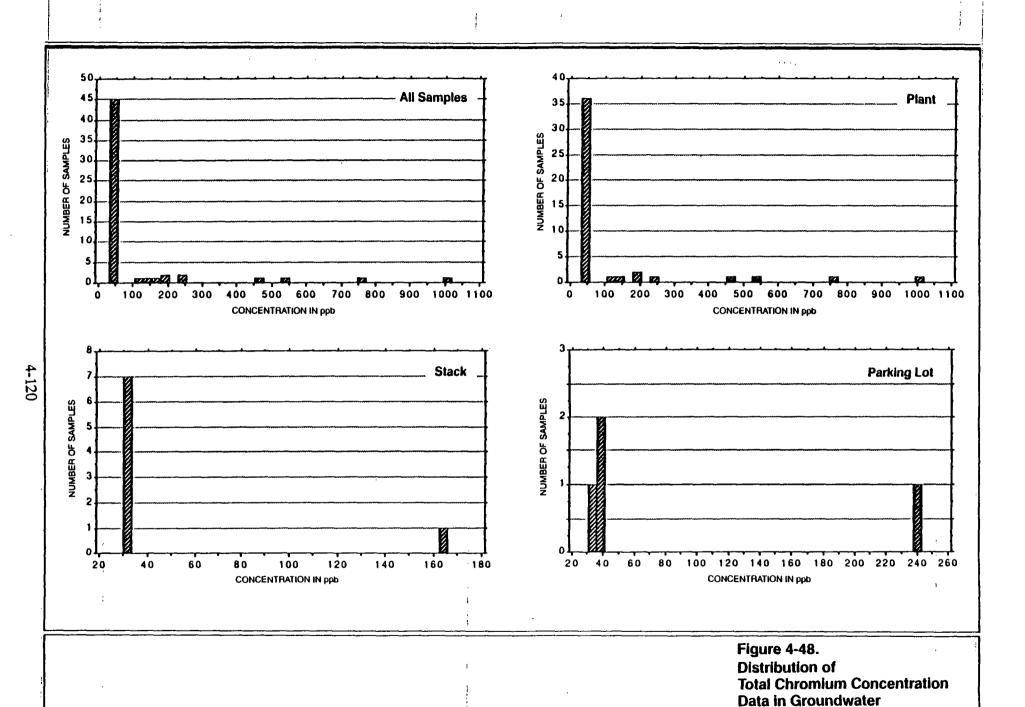


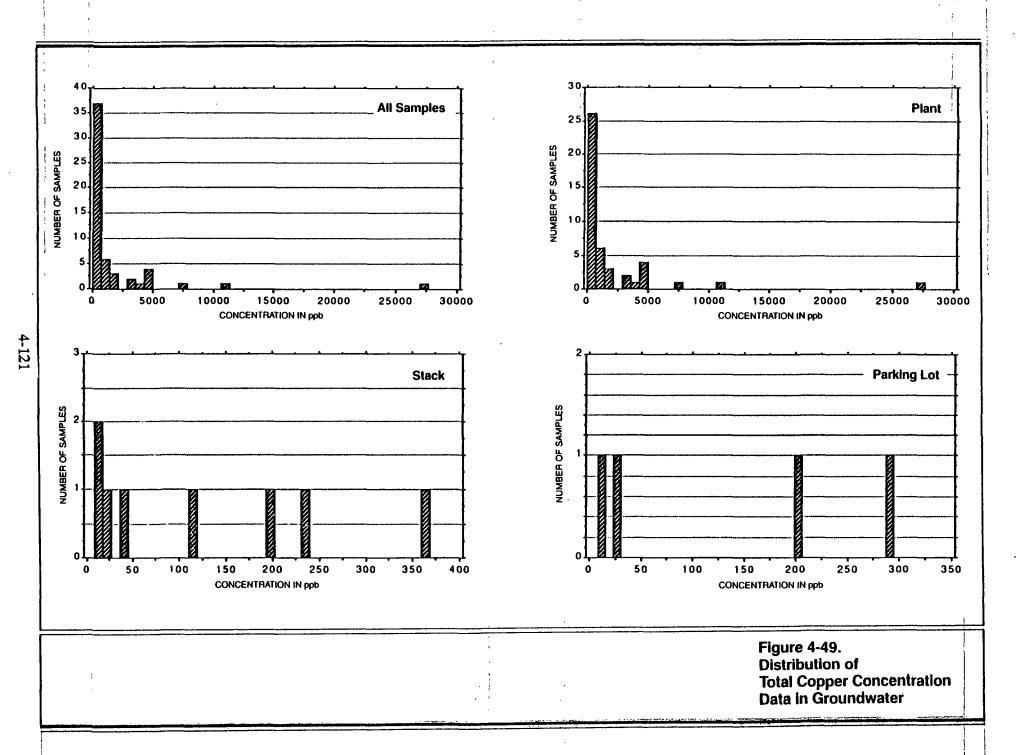


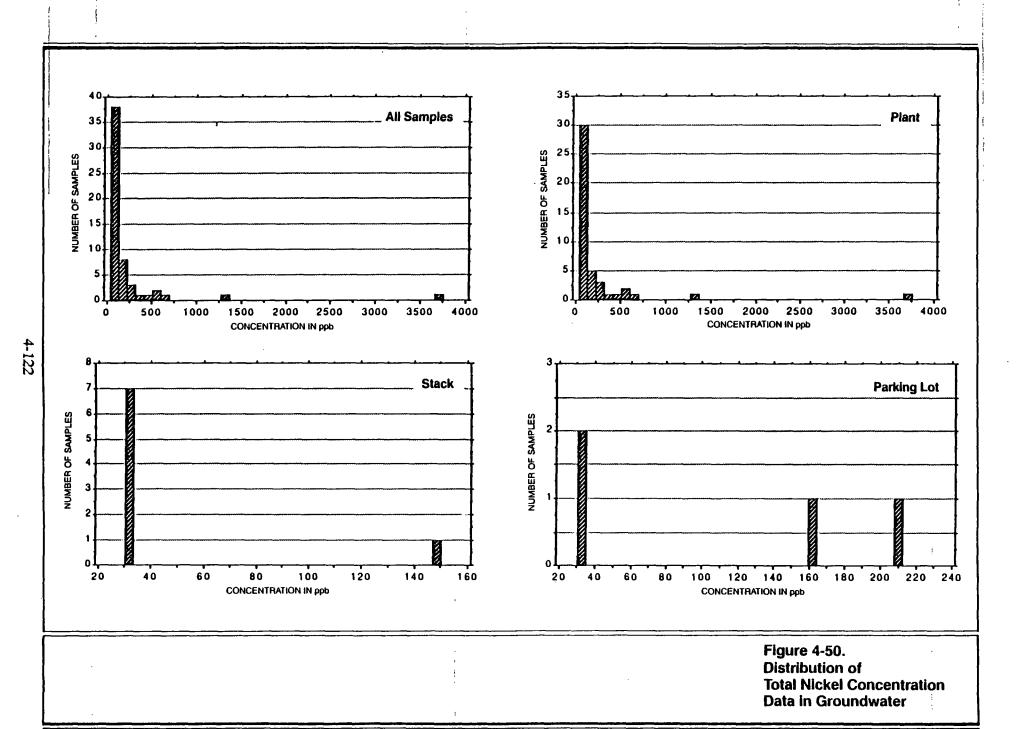


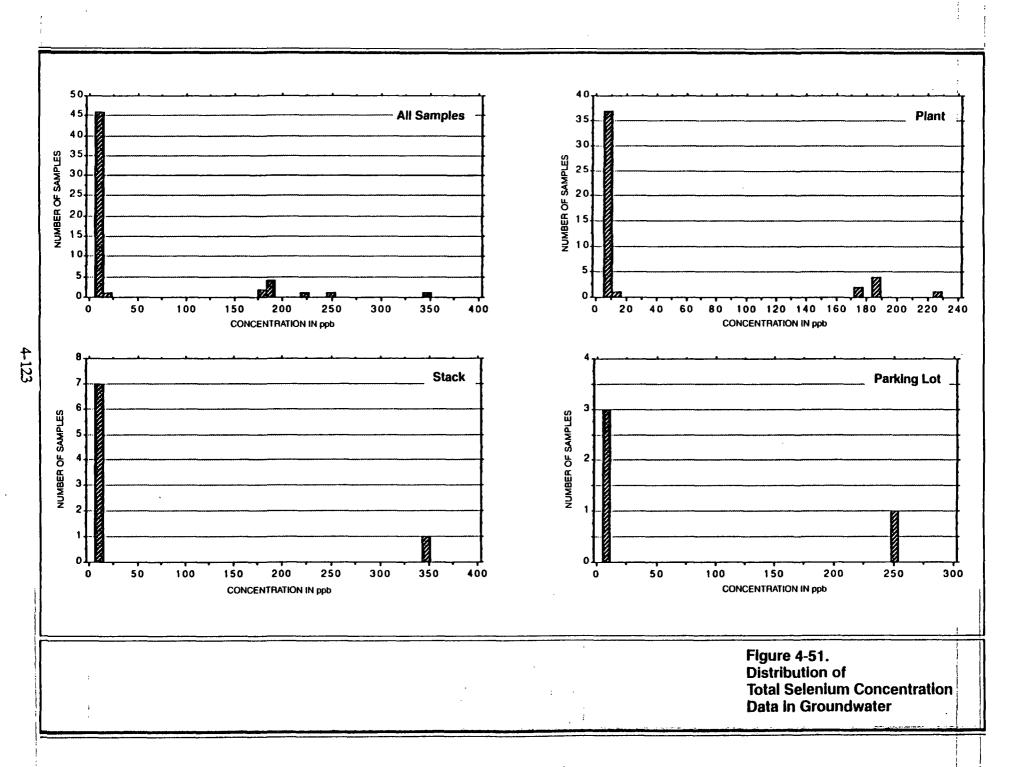


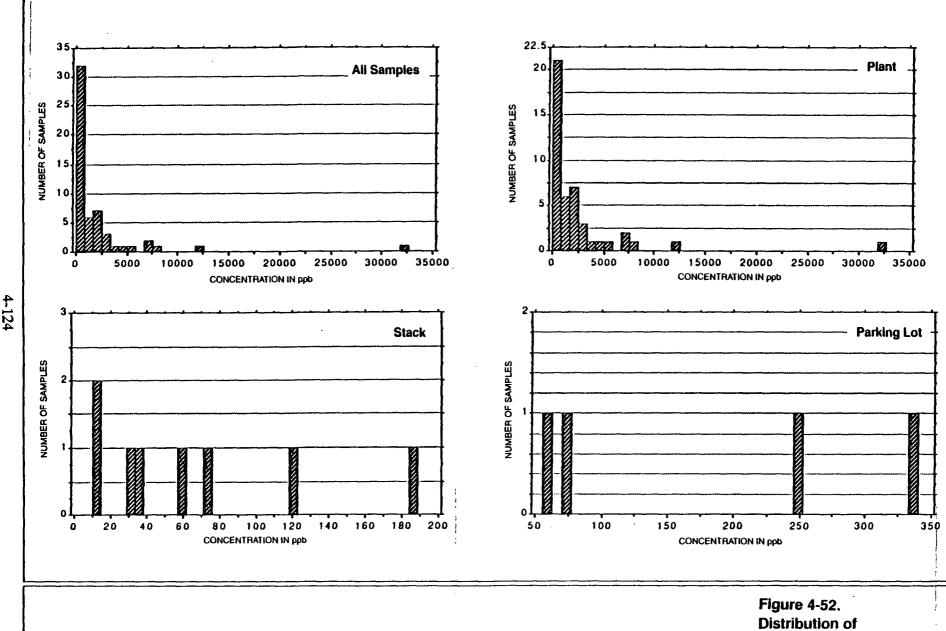




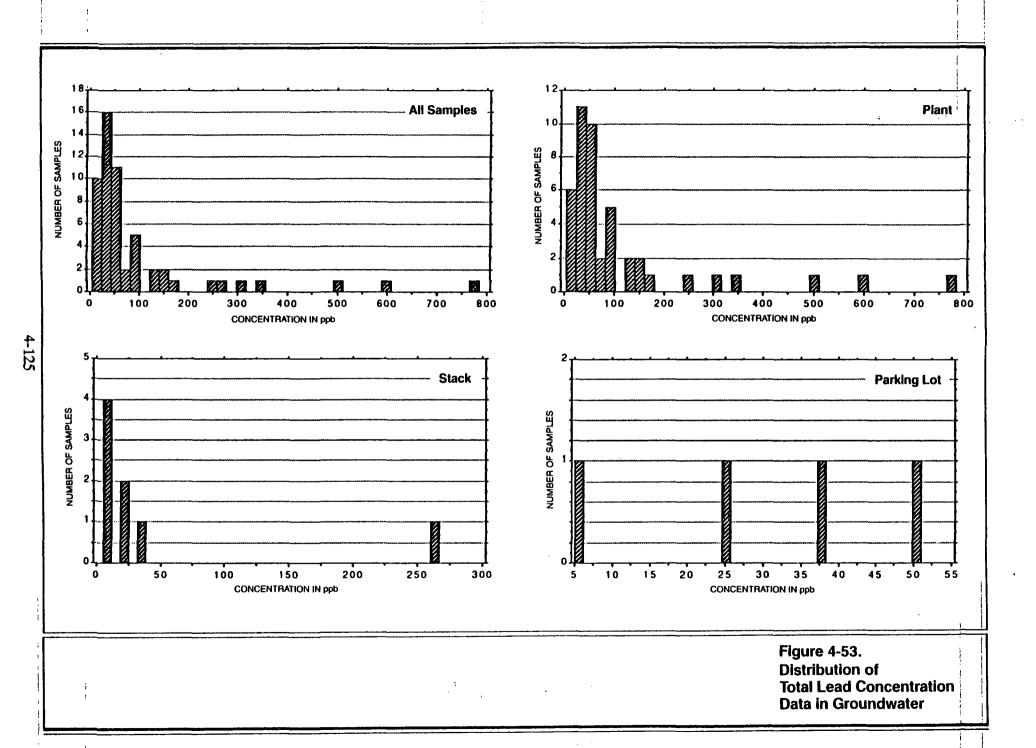


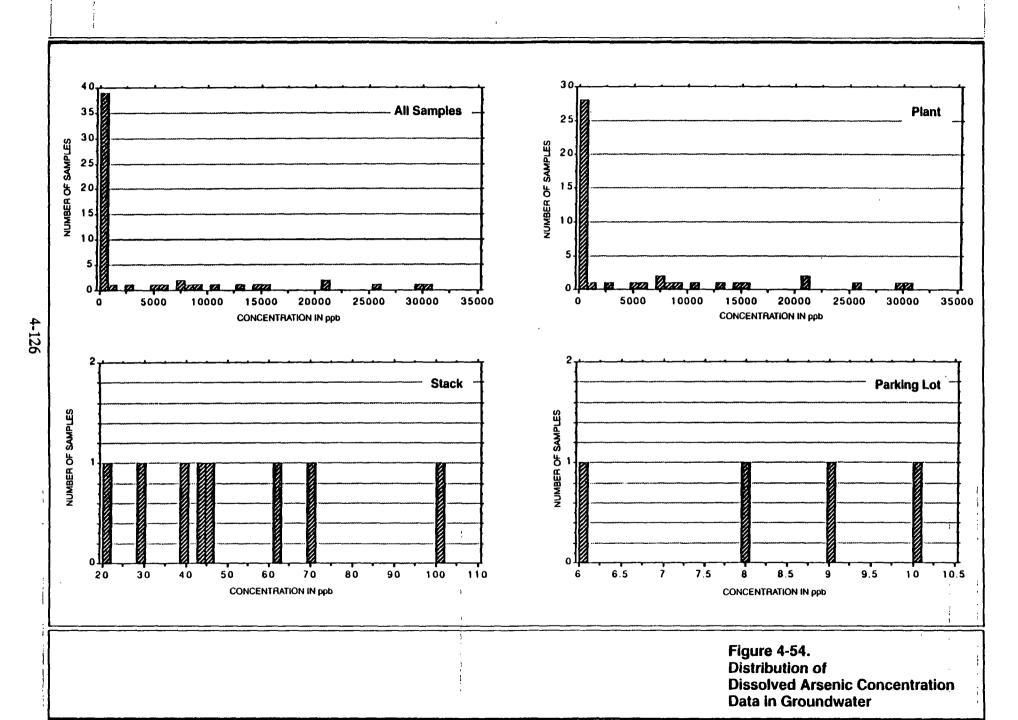


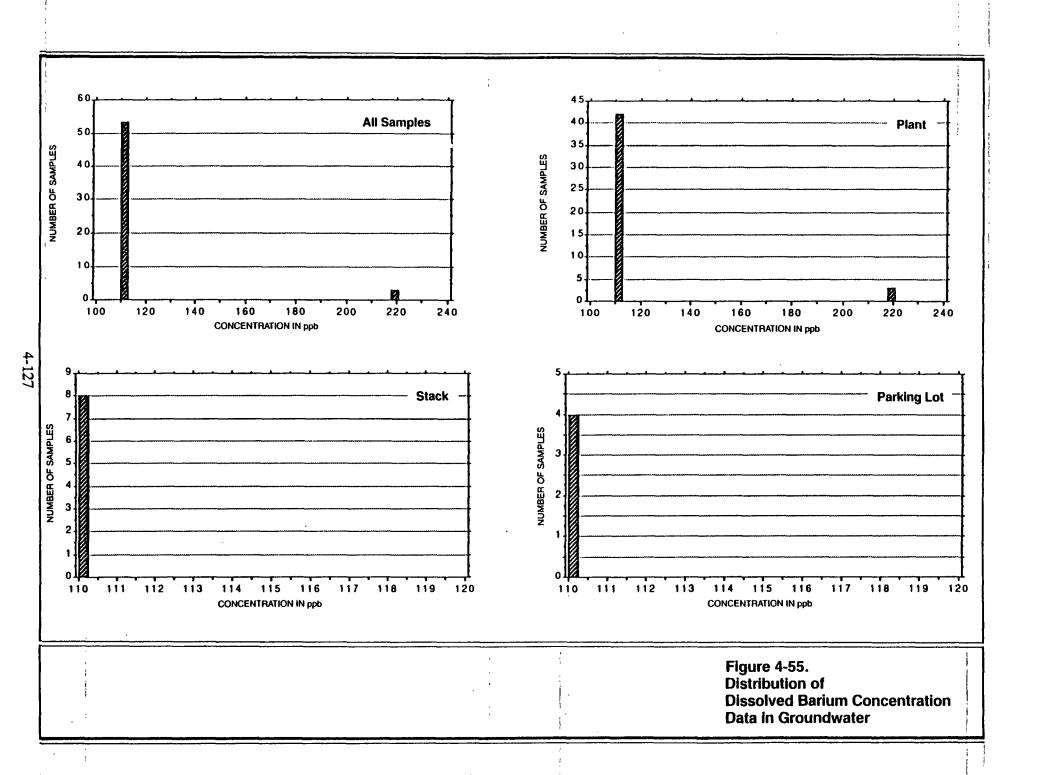


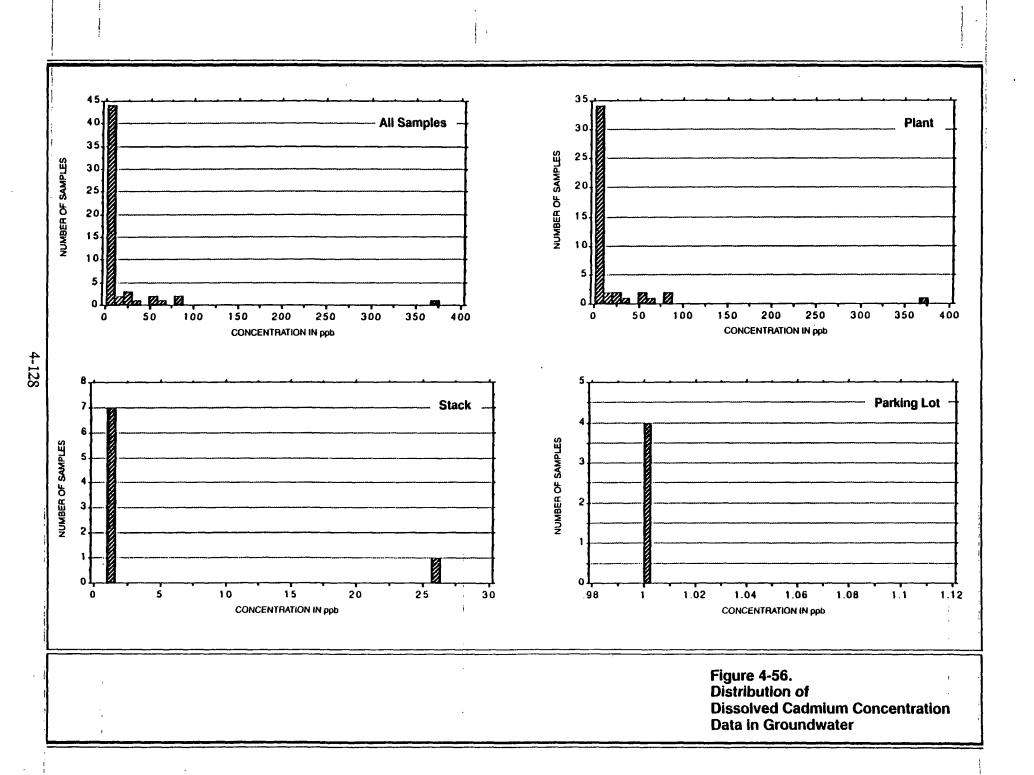


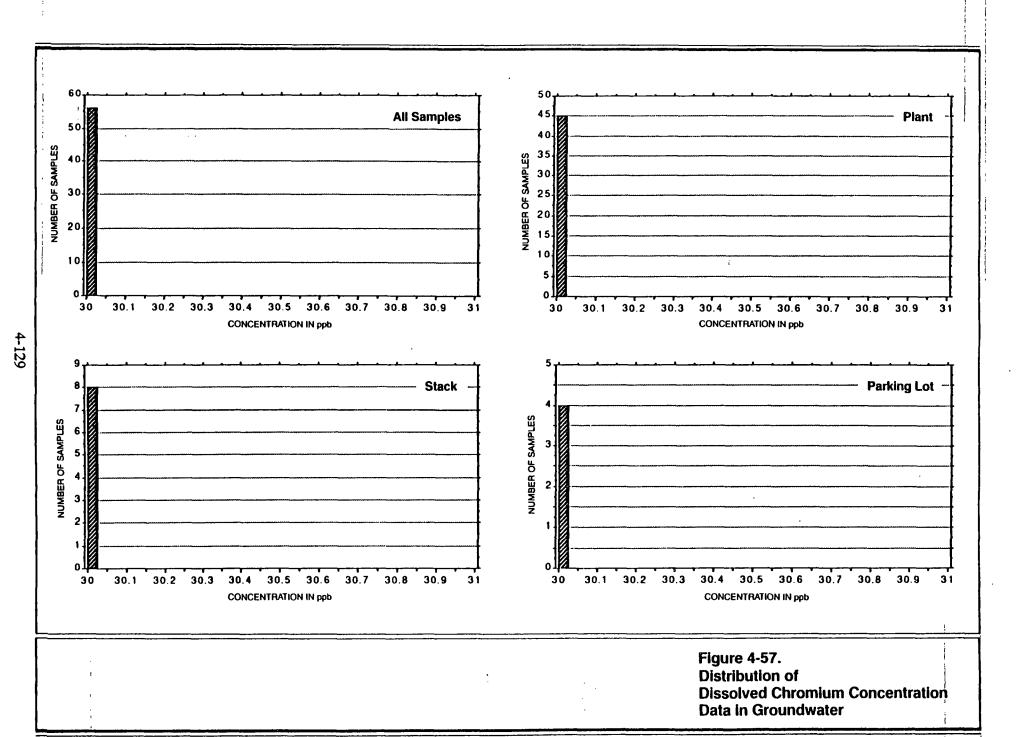
**Total Zinc Concentration Data in Groundwater** 













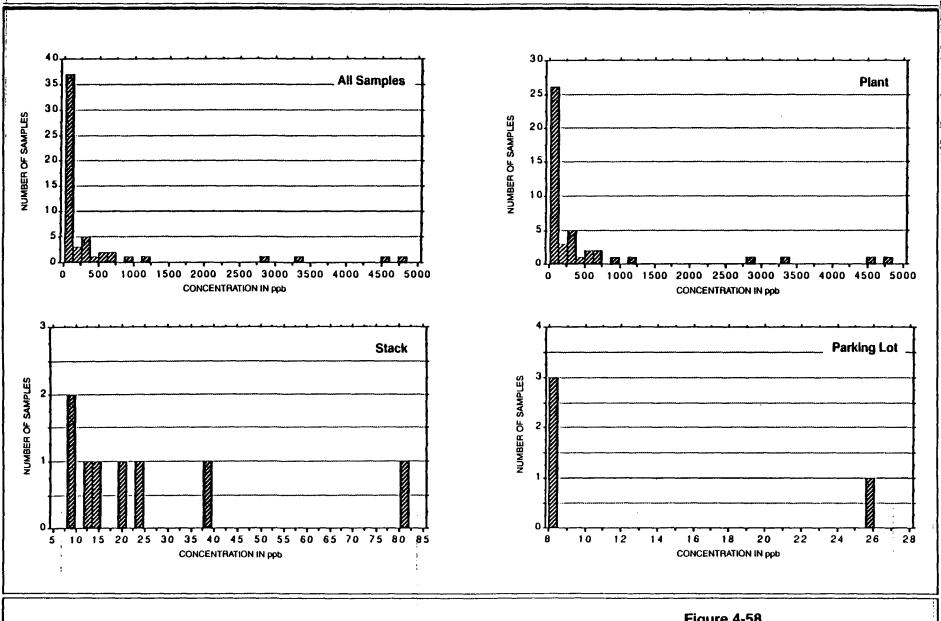
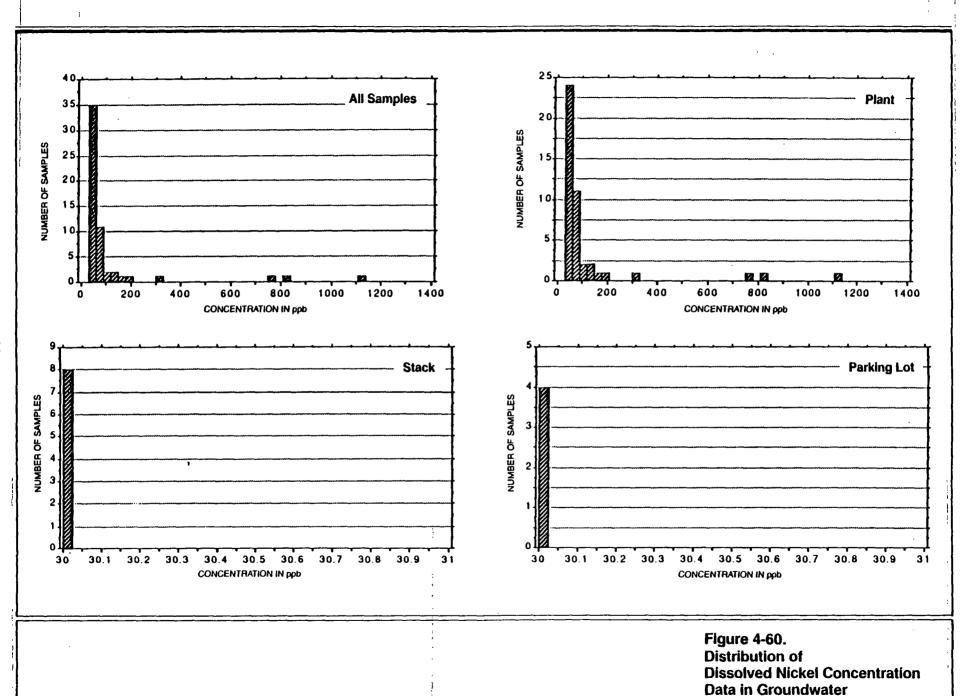


Figure 4-58.
Distribution of
Dissolved Copper Concentration
Data in Groundwater

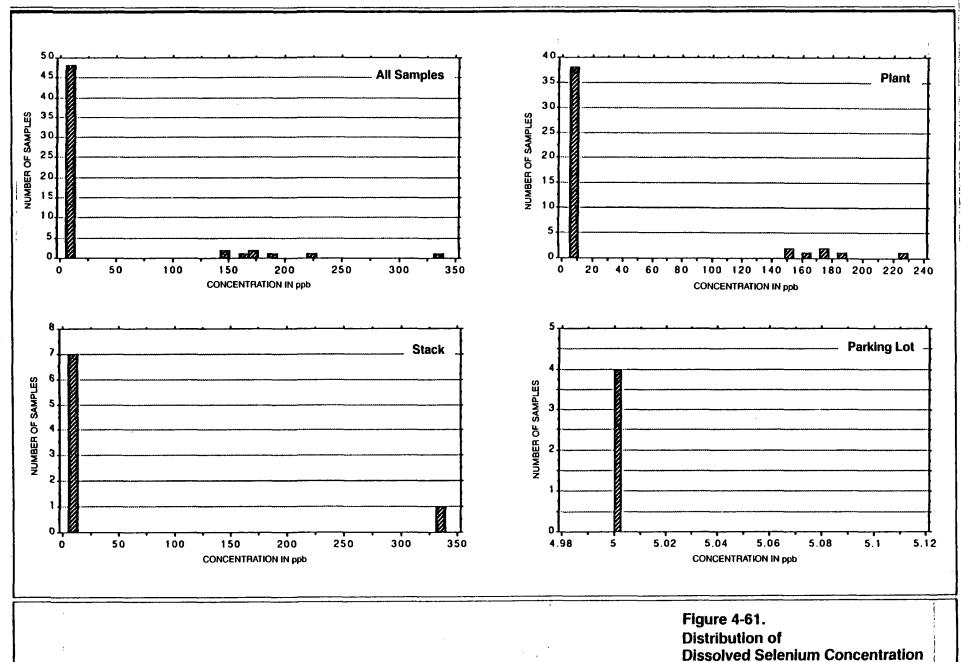
5.12

**Data in Groundwater** 



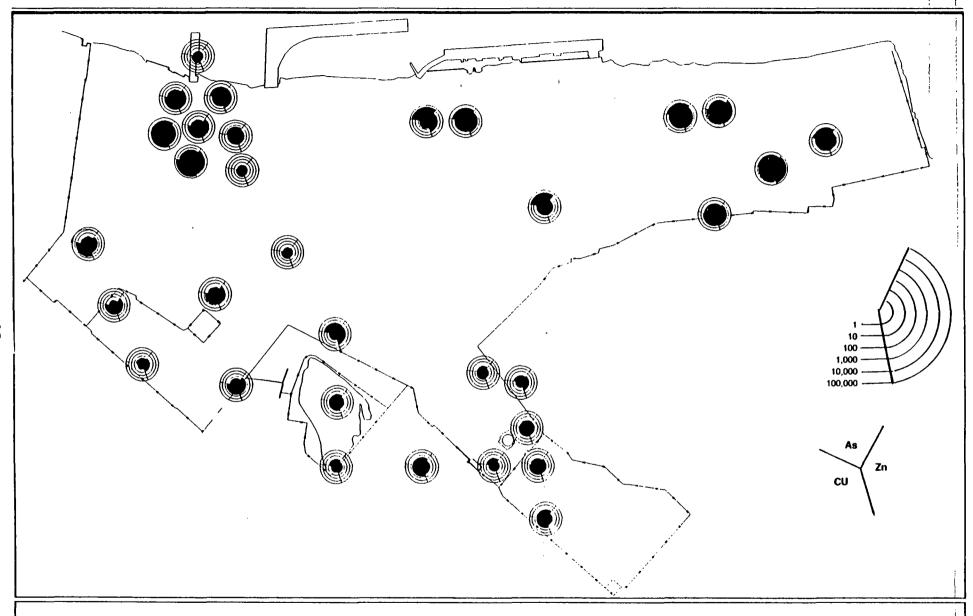






**Data in Groundwater** 

**Data in Groundwater** 

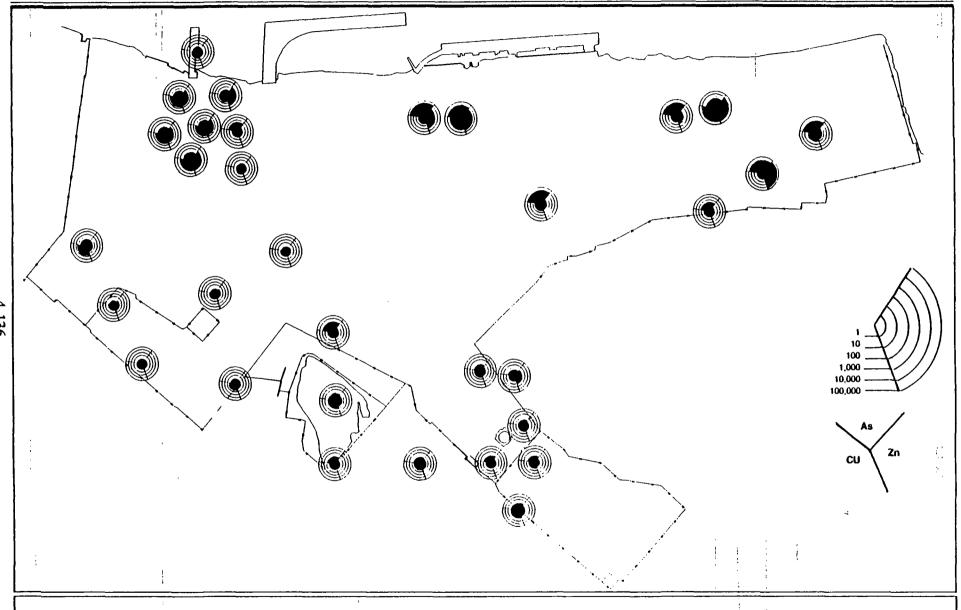


Arsenic Detection Limit — 6.0 ppb

Copper Detection Limit — 8.0 ppb

Zinc Detection Limit — 8.0 ppb

Figure 4-63. Total Arsenic, Copper, and Zinc in Ground Water

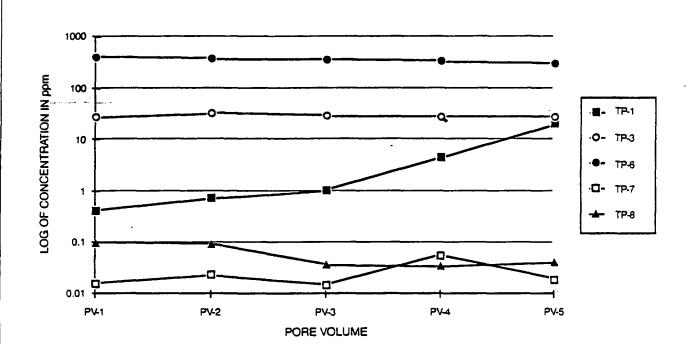


Arsenic Detection Limit — 6.0 ppb

Copper Detection Limit — 8.0 ppb

Zinc Detection Limit — 8.0 ppb

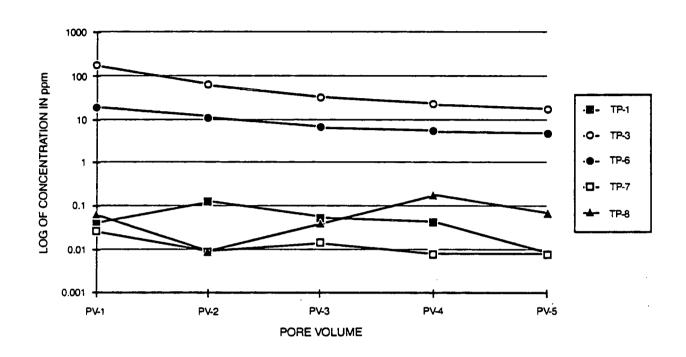
Figure 4-64.
Dissolved Arsenic,
Copper, and Zinc in Ground Water



## Soil Arsenic Concentrations

Test Pit Number	Matrix	Totai (in ppm)	EP Toxicity (in ppm)	Leaching Test (in ppm)
TP-1	Granular Fill	2,305	0.027	5.3
TP-3	Granular Fill	4,200	3.5	29
TP-6	Granular Fill	30,375	31	353
TP-7	Granular Fill	10	0.033	0.026
TP-8	Slag Fill	9,950	0.013	0.061

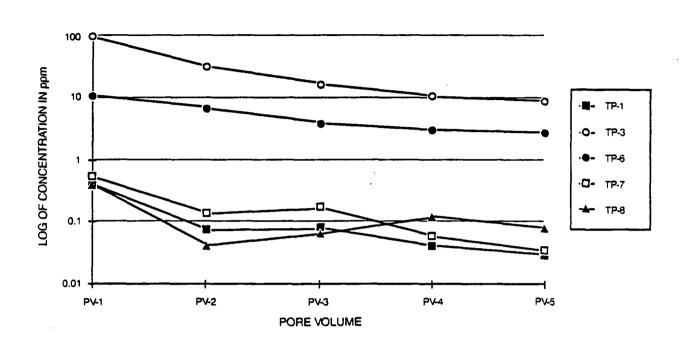
Figure 4-66.
Dissolved Arsenic Concentrations in Leachate Water



Call	C	Concentrations
Soli	Copper	Concentrations

Test Pit Number	Matrix	Total (in ppm)	EP Toxicity (in ppm)	Leaching Test (in ppm)
TP-1	Granular Fill	217	0.024	0.055
TP-3	Granular Fill	1,633	4.2	63
TP-6	Granular Fill	515	0.99	9.4
TP-7	Granular Fill	136	ND	0.013
TP-8	Slag Fill	45,250	1.6	0.073

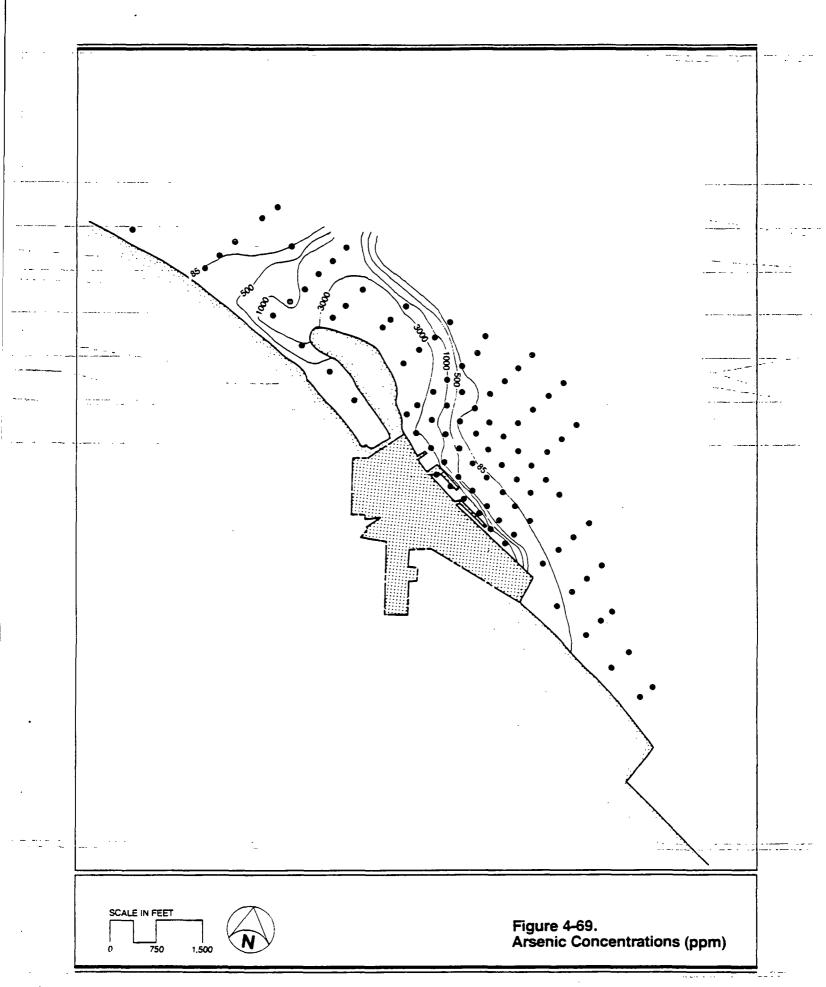
Figure 4-67.
Dissolved Copper Concentrations in Leachate Water



0 - 31	71	O	
2011	ZINC	Concentrations	ì

Test Pit Number	Matrix	Totai (in ppm)	EP Toxicity (in ppm)	Leaching Test (in ppm)
TP-1	Granular Fill	263	0.012	0.125
TP-3	Granular Fill	400	2.1	33
TP-6	Granular Fill	150	0.67	5.4
TP-7	Granular Fill	398	0.24	0.19
TP-8	Slag Fill	20.400	0.11	0.14

Figure 4-68.
Dissolved Zinc Concentrations in Leachate Water



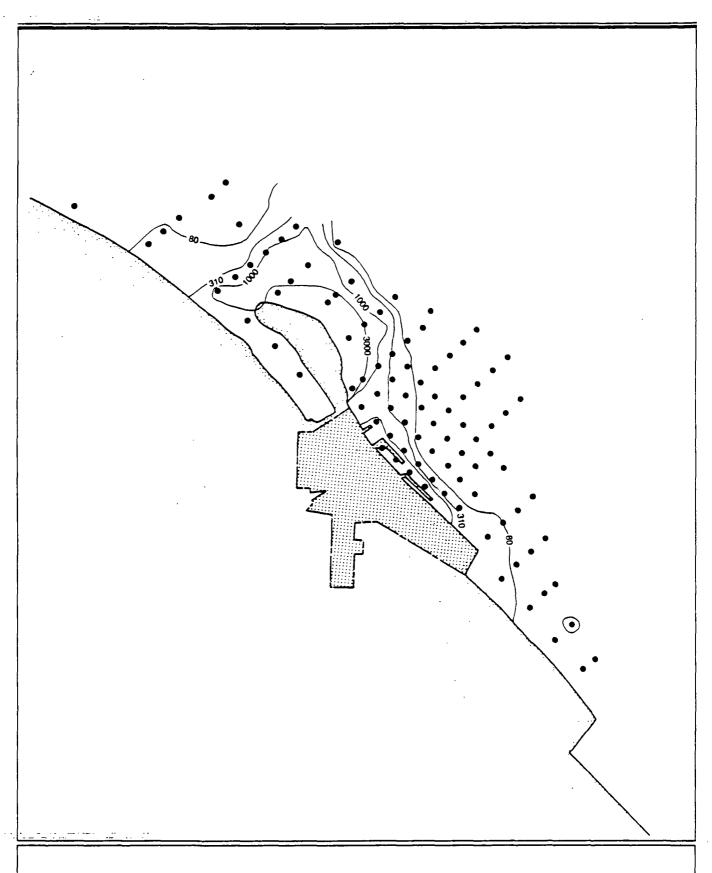
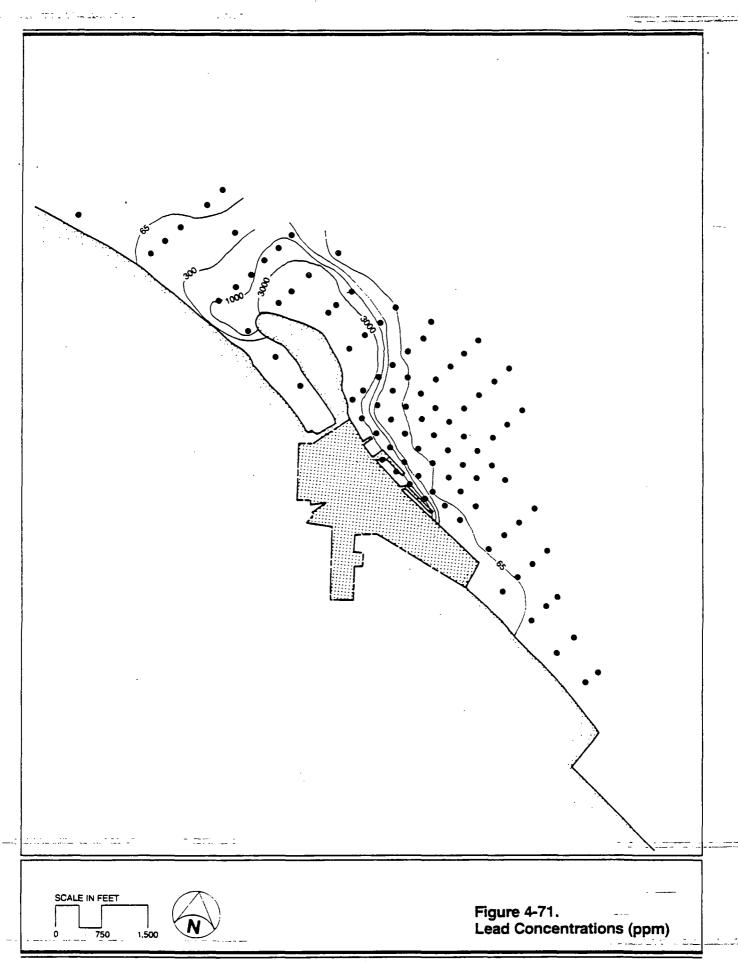




Figure 4-70.
Copper Concentrations (ppm)



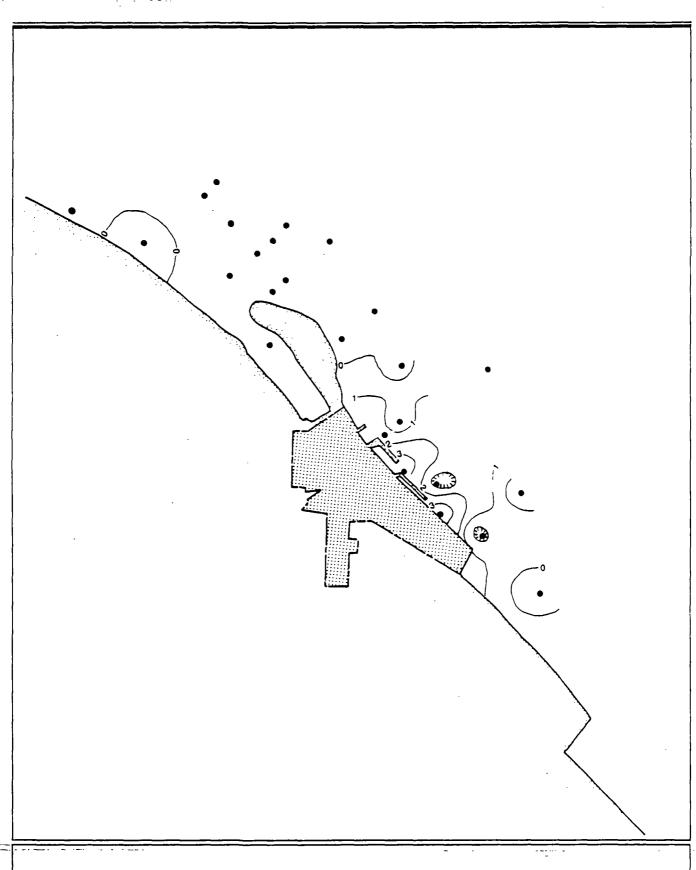
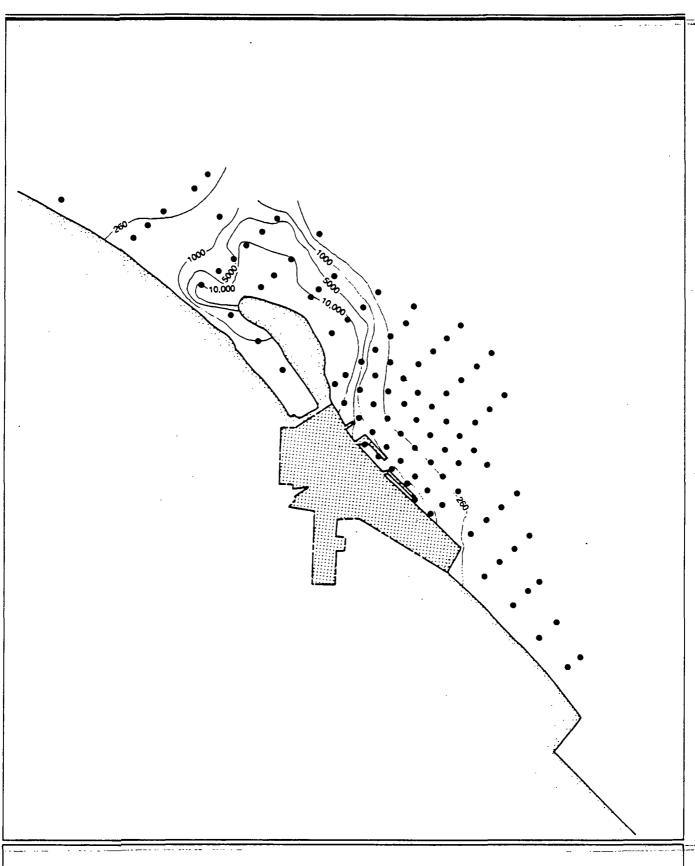




Figure 4-72.
Mercury Concentrations (ppm)



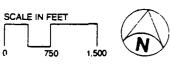
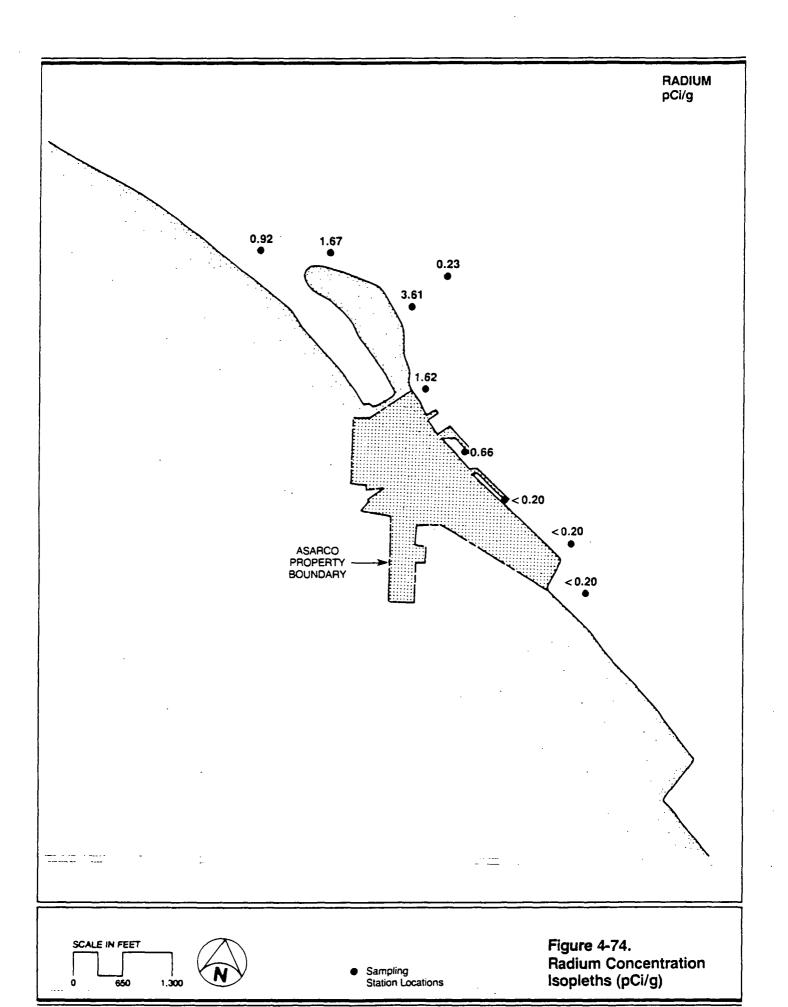


Figure 4-73.
Zinc Concentrations (ppm)



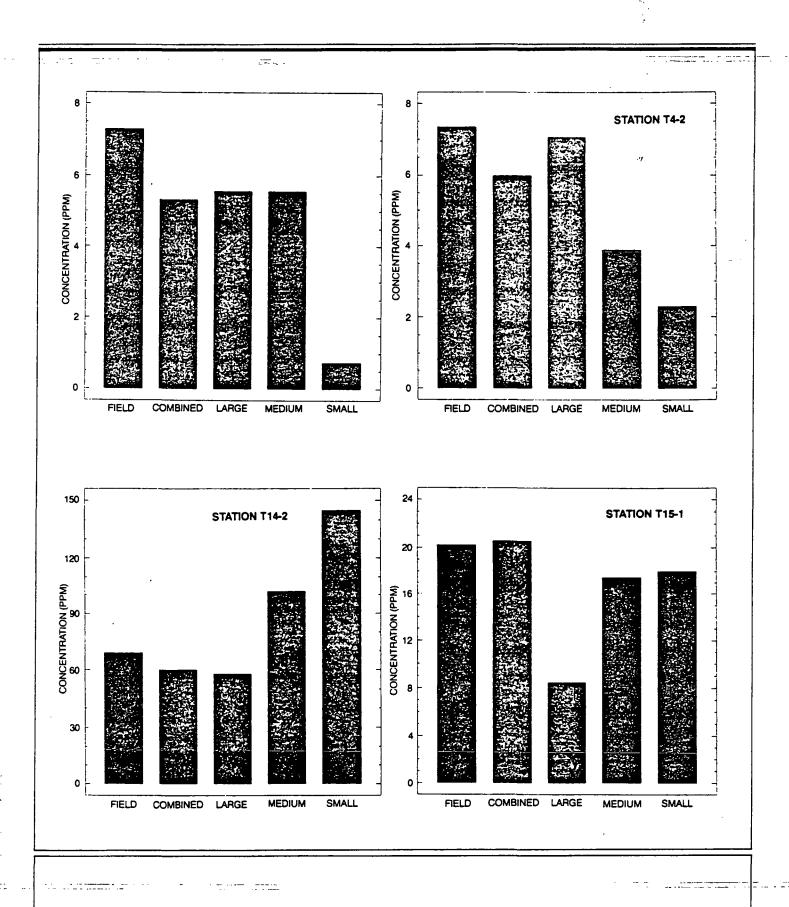


Figure 4-75.
Results of Marine Sediment Slag
Separation Samples Analyzed for Arsenic

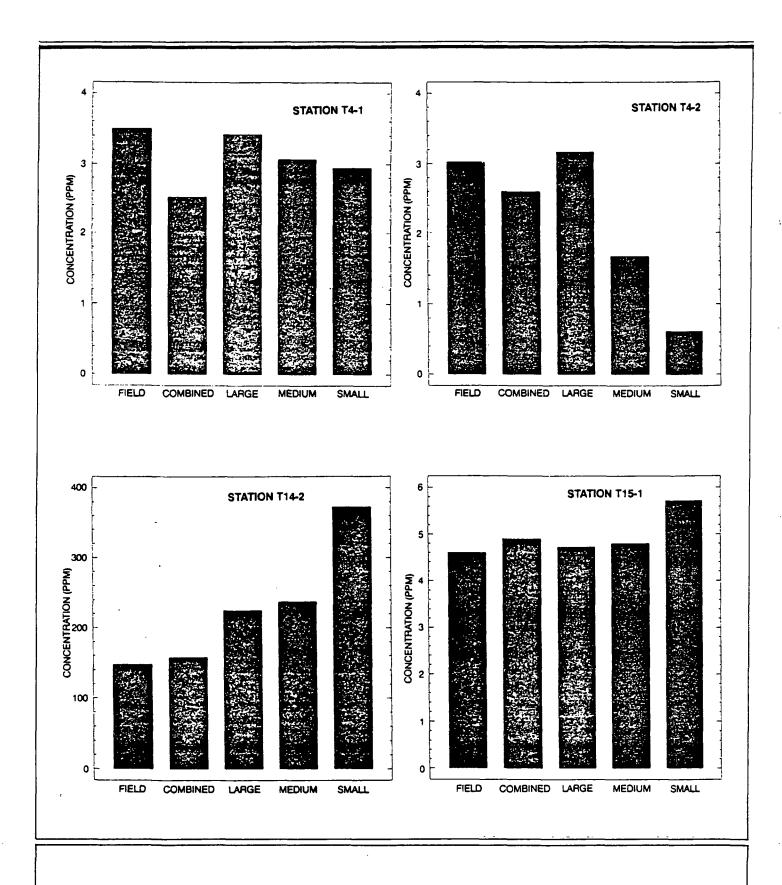


Figure 4-76.
Results of Marine Sediment Slag
Separation Samples Analyzed for Copper

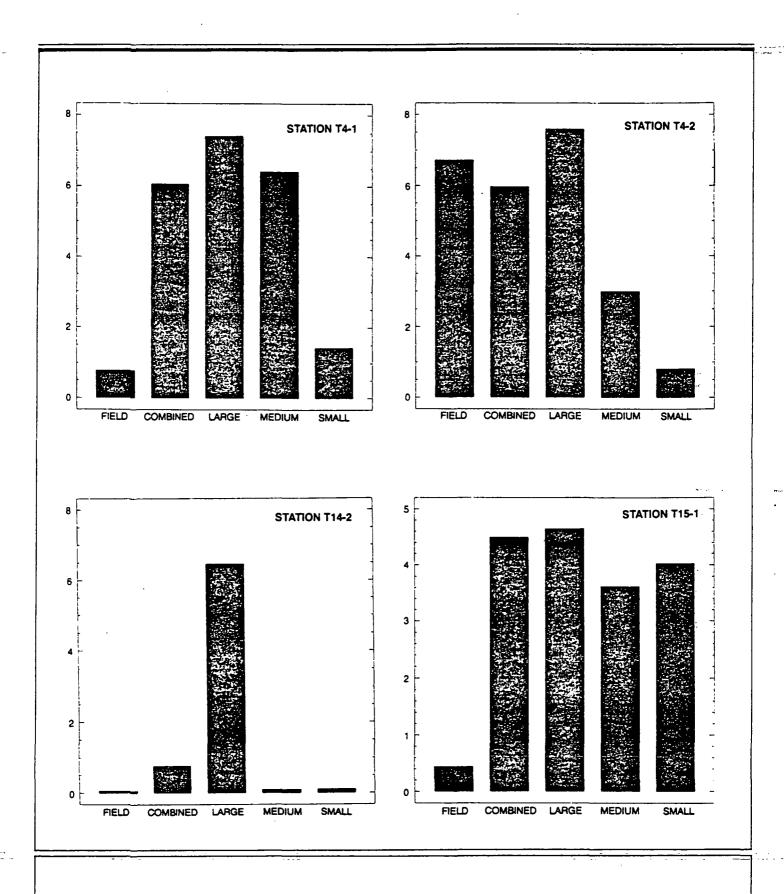


Figure 4-77.
Results of Marine Sediment Slag
Separation Samples Analyzed for Lead

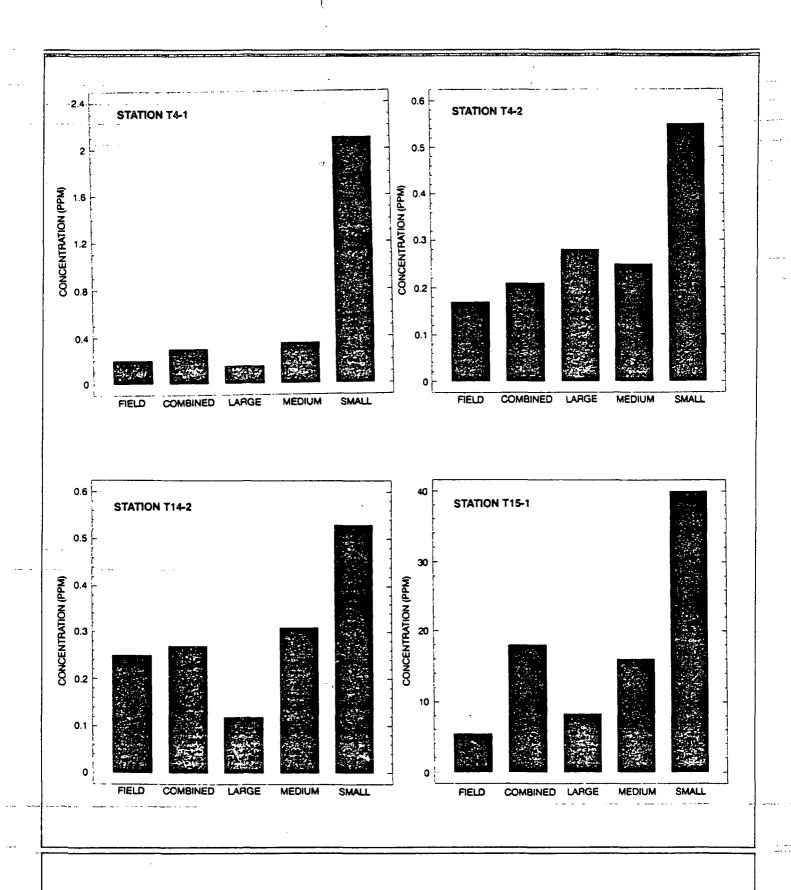


Figure 4-78.
Results of Marine Sediment Slag
Separation Samples Analyzed for Mercury

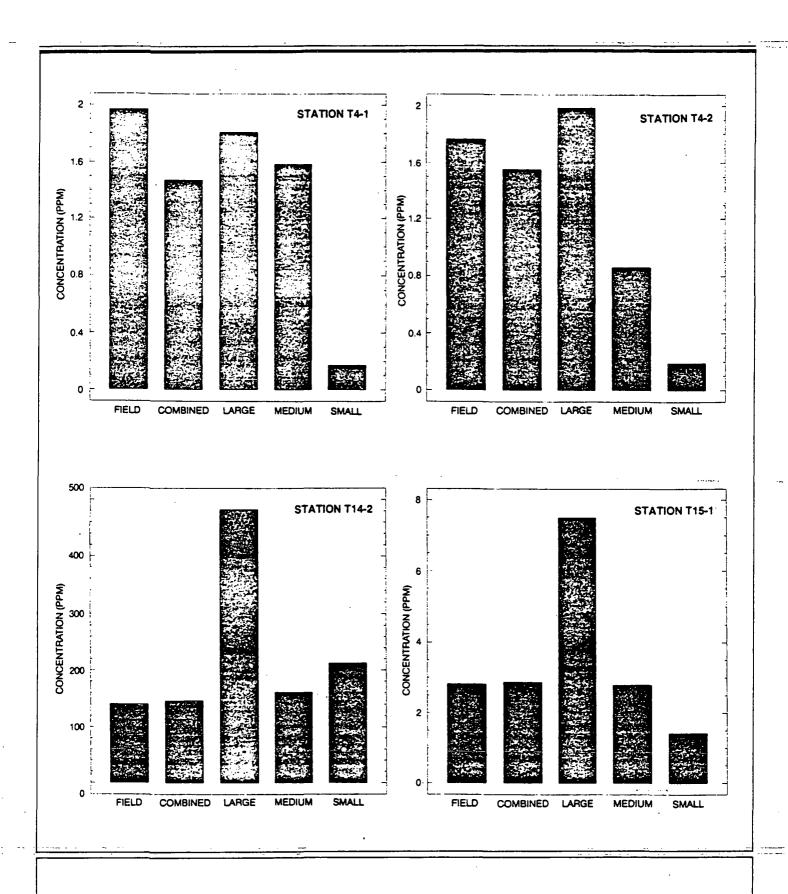
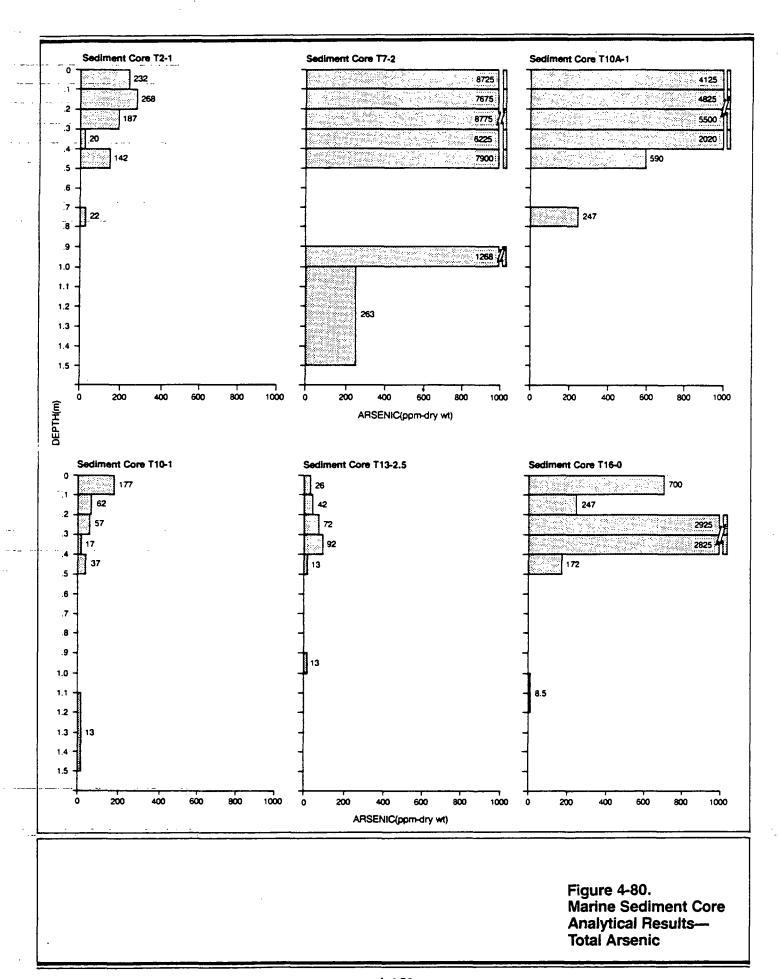


Figure 4-79.
Results of Marine Sediment Slag
Separation Samples Analyzed for Zinc



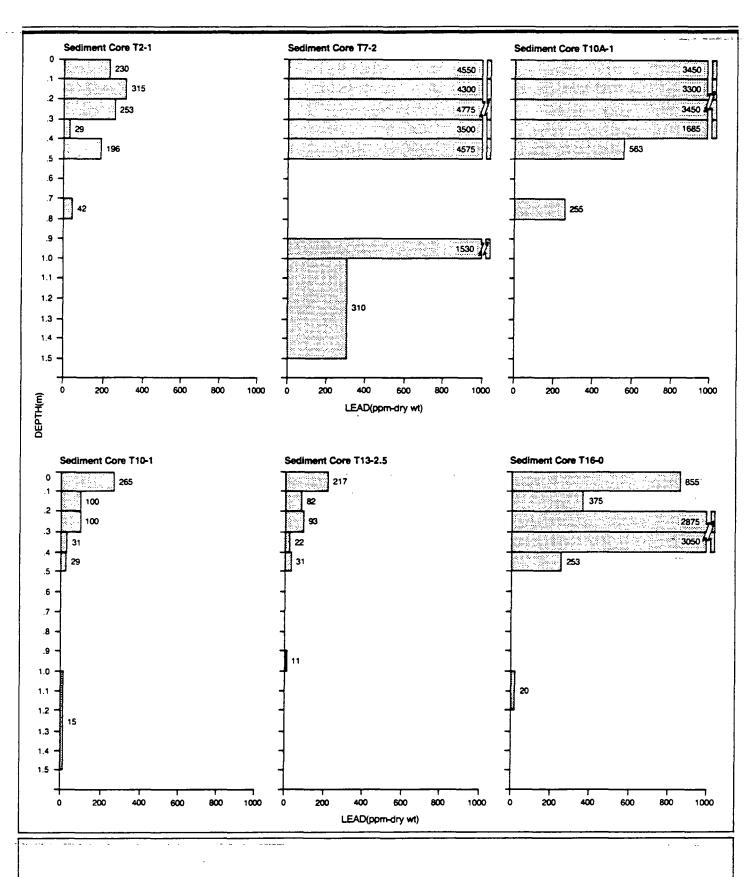


Figure 4-81.
Marine Sediment Core
Analytical Results —
Total Lead

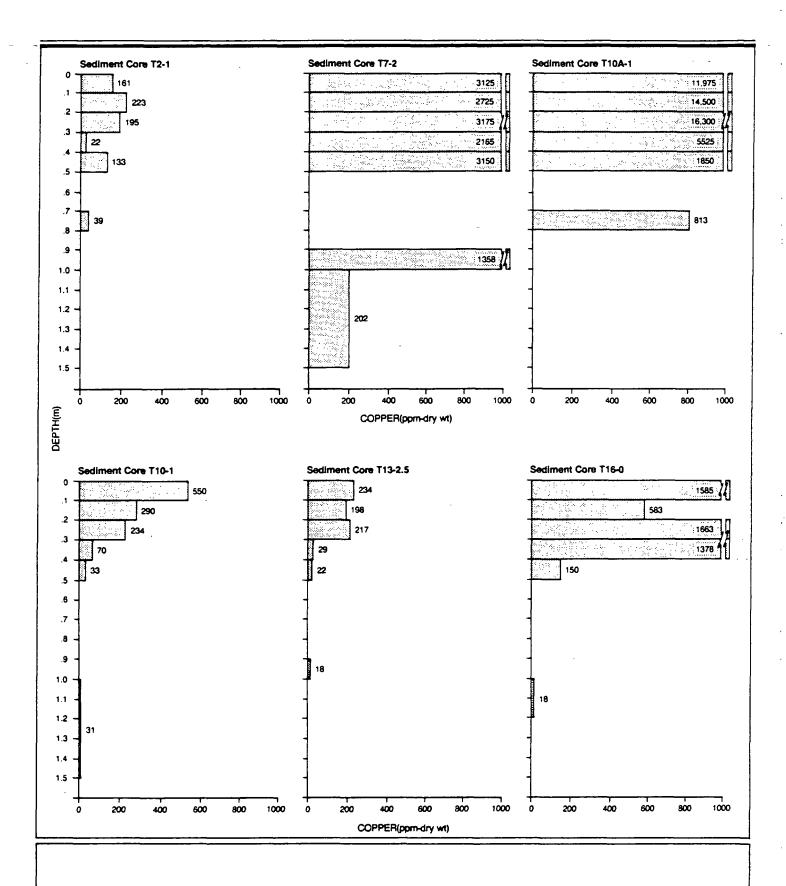
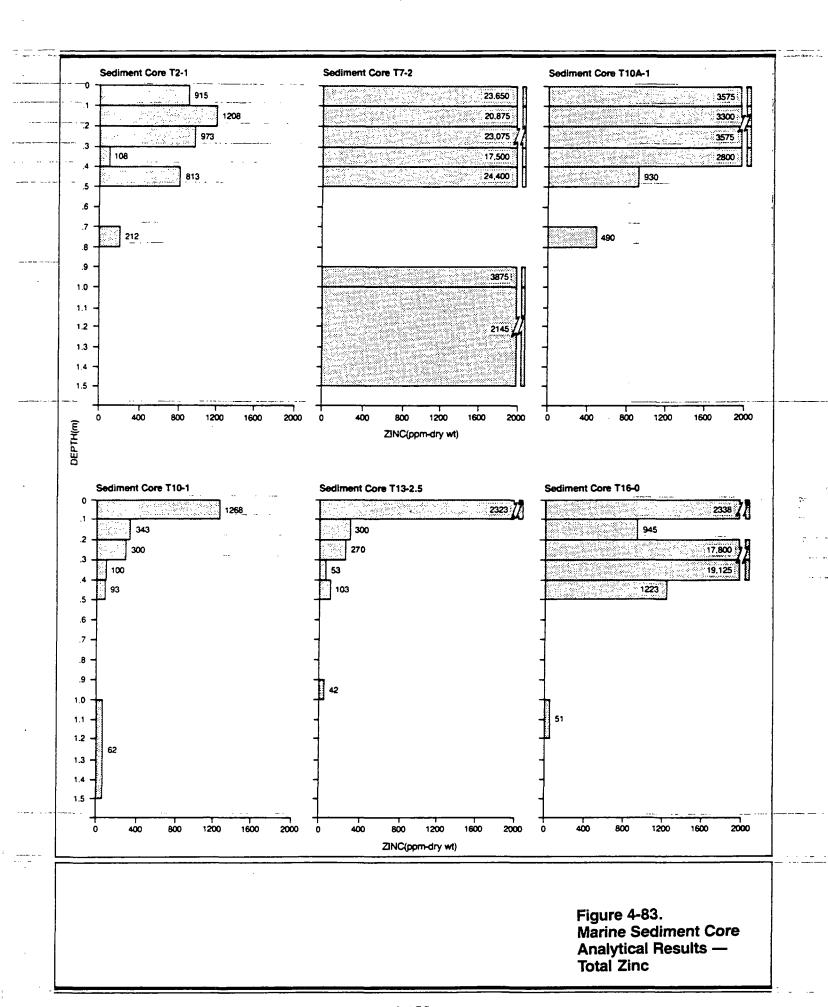
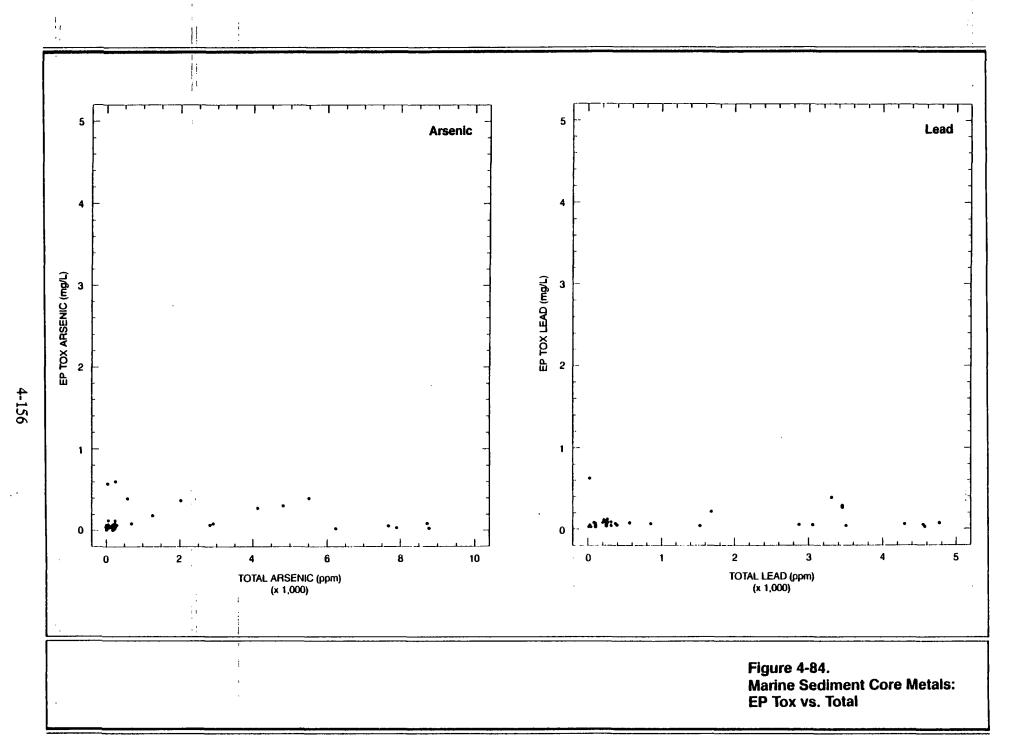
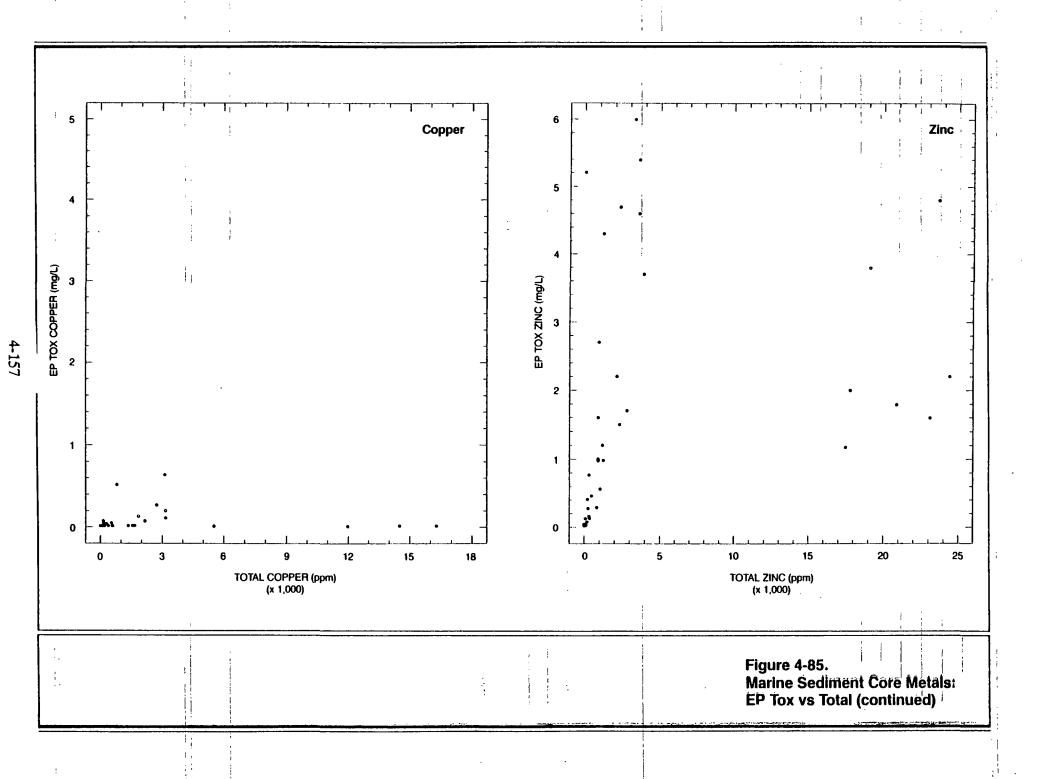
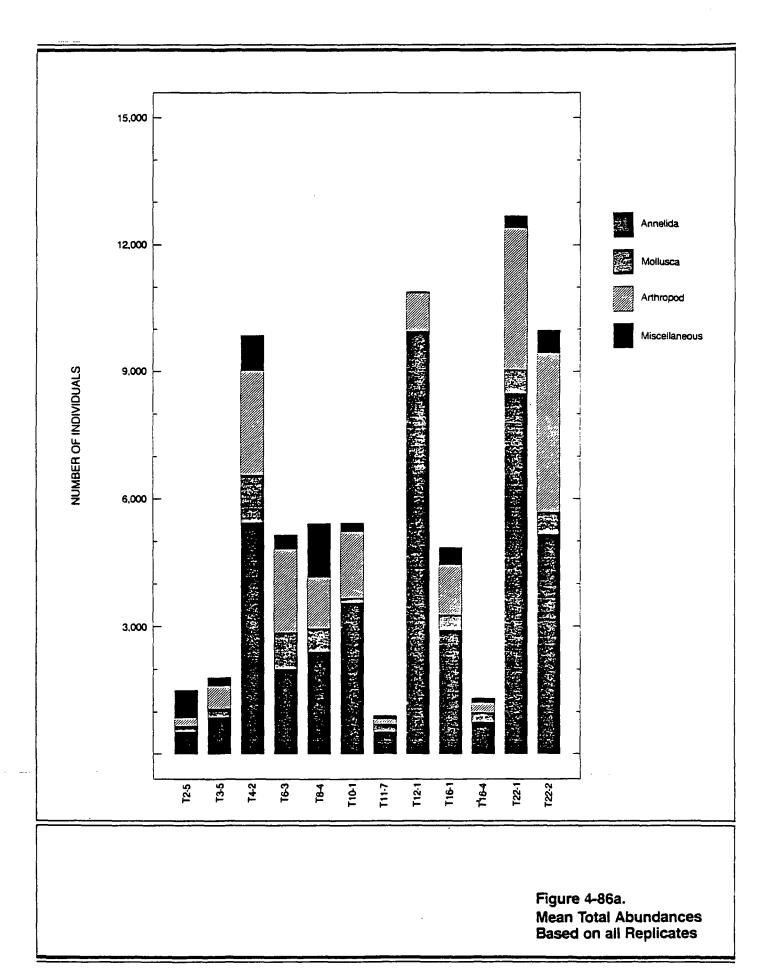


Figure 4-82.
Marine Sediment Core
Analytical Results —
Total Copper









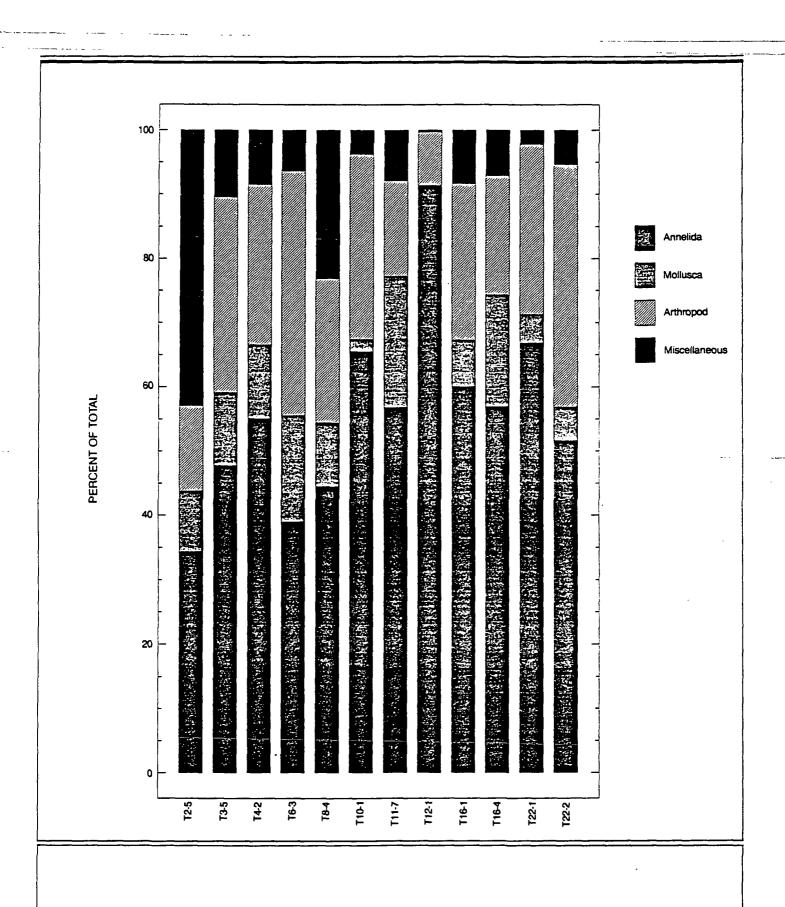
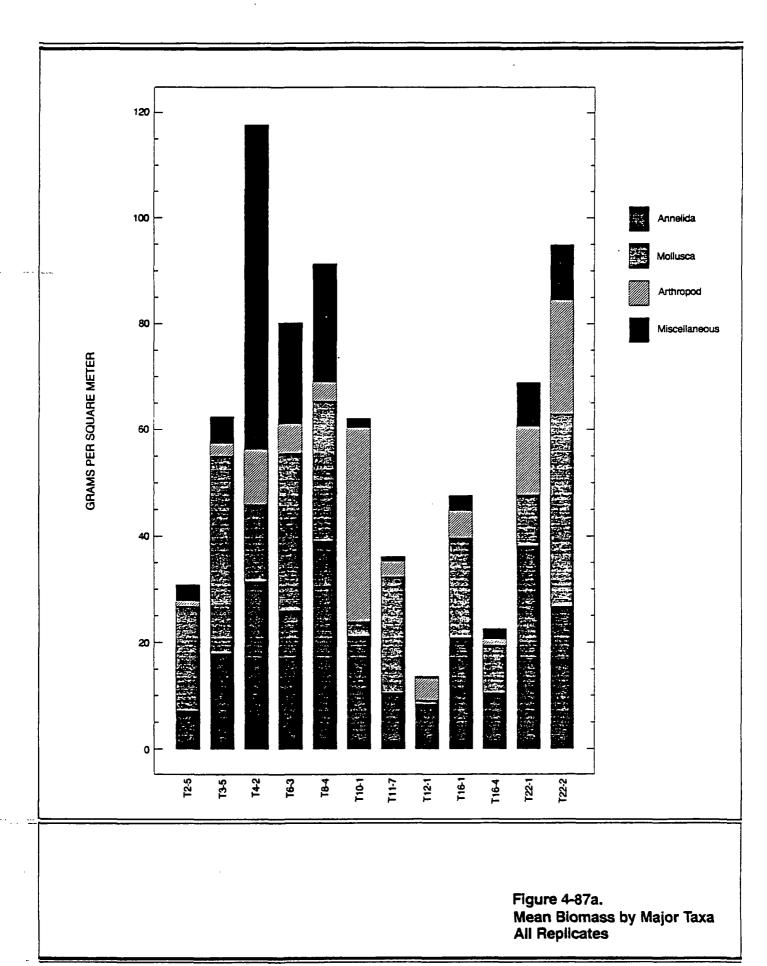


Figure 4-86b.
Proportional Abundances
Based on Replicate Mean Abundances



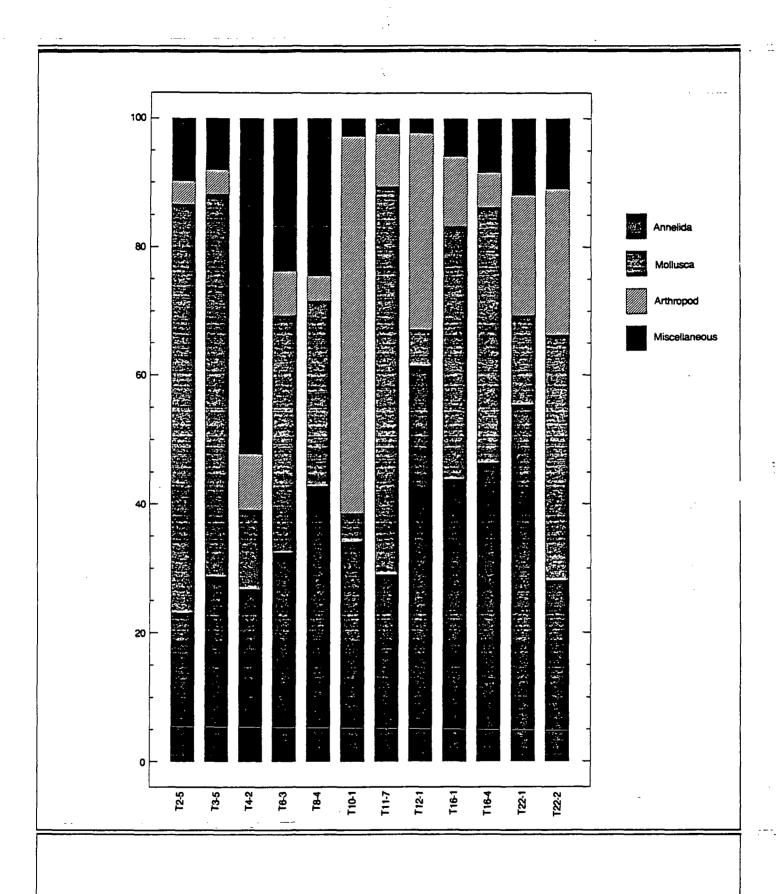


Figure 4-87b.
Proportional Biomass of Major Taxa
All Replicates

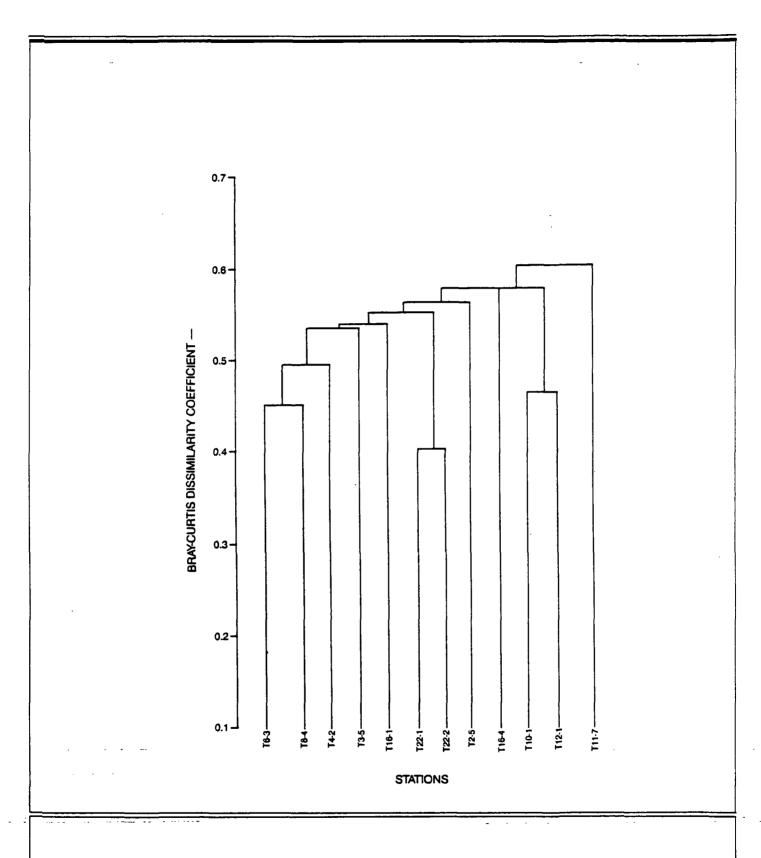


Figure 4-88.
Nearest Neighbor
Clusters of Stations Based
on In Transformed Benthic
Organism Abundances

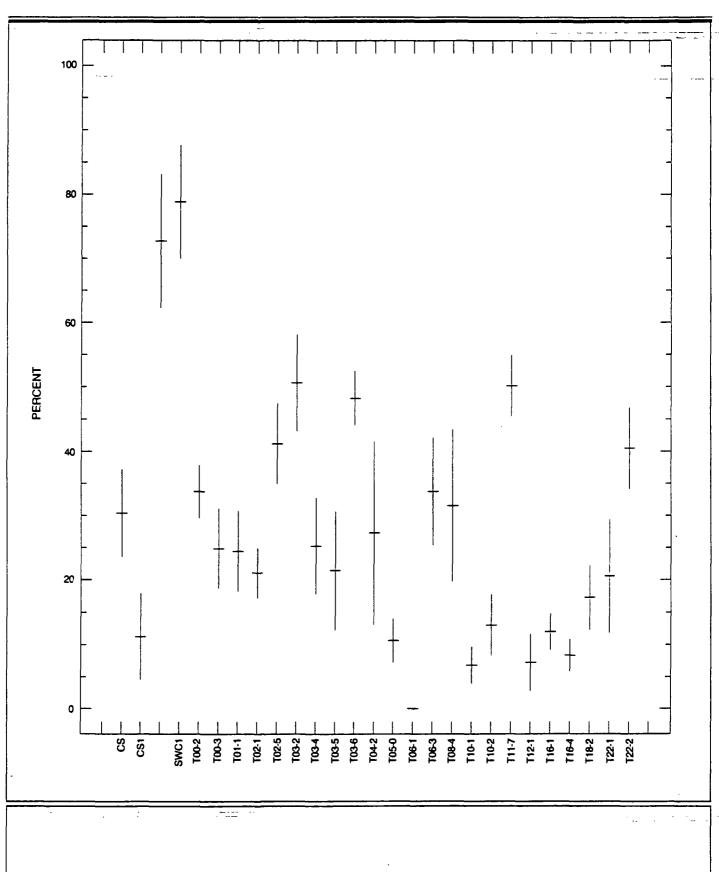


Figure 4-89.
Percent of Oyster Larvae Surviving
Standard Error of Each Sample Indicated

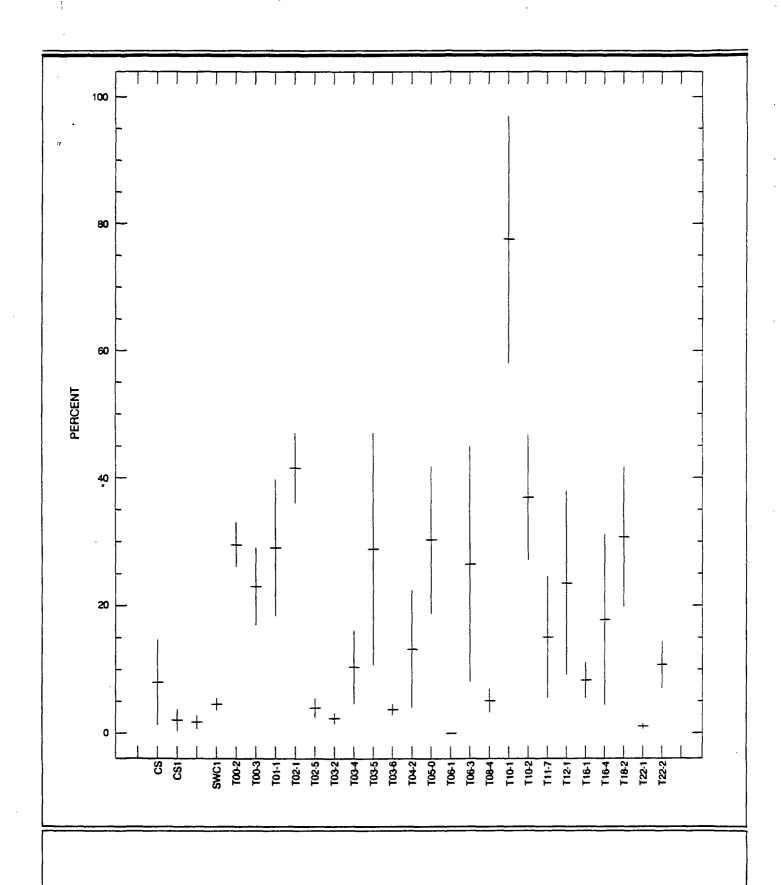
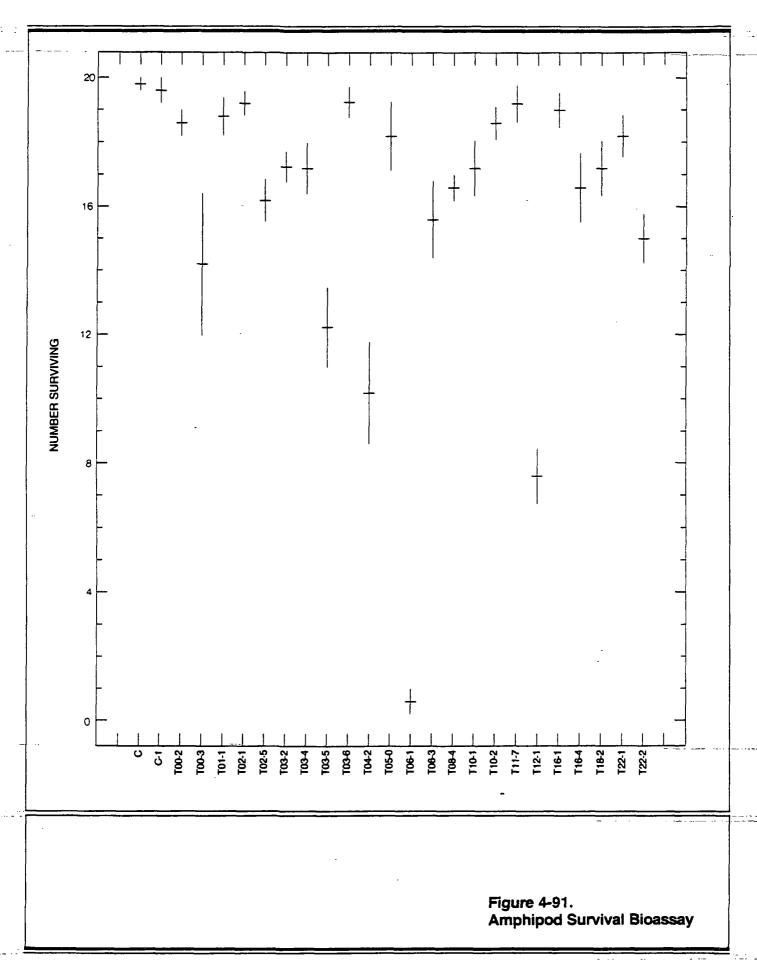


Figure 4-90.

Percent of Oyster Larvae that are Abnormal Standard Error of Each Sample Indicated



### 5.0 CONTAMINANT FATE AND TRANSPORT

### 5.1 POTENTIAL ROUTES OF MIGRATION

### 5.1.1 SUMMARY OF NATURE OF AIR CONTAMINATION

Air emissions from the inactive smelter site are primarily fugitive dust particles. Fugitive (or wind-blown) dust can be released from a site if wind velocities are high enough to lift particles from the surface. Fugitive dust is also released if agitated by work activities or work vehicles moving about the site. Most fugitive dust particles are large and will return to the surface close to where they were suspended. Smaller particles, less than  $2.5 \mu$  in diameter, will travel several kilometers before returning to the surface. Dust particles being blown from the Asarco site contain elevated levels of metals such as antimony, arsenic, chromium, cadmium, copper, lead, and nickel.

Fugitive emissions from the Asarco plant have been quantified several times in the past, focusing on process fugitive emissions during plant operations. In 1983, Dr. Cowherd of MRI performed an EPA-sponsored soils analysis on site to characterize plant emissions. Cowherd based his analysis on 16 samples taken in the areas previously occupied by the converter plate treater, pipe treater, cottrell plate treater, stack, the metallic arsenic plant and bag house, storage bins, and at street locations outside of the plant. Specific substances such as reverberatory slag, lime rock, and cottrell dust were sampled to gain an understanding of the soils at Asarco. The samples were analyzed to determine silt content and cloddiness. Cloddiness was used to determine sample erodibility.

The analysis also reviewed the crusting potential of the particulate matter at the site. One of the major deficiencies acknowledged in the report was that soil composition and particle size distributions needed to be determined.

In 1987, NEA, Inc. conducted the recommended particle size distribution and particle composition analysis. Samples were collected from 22 locations, including the area previously sampled by MRI. However, most of the facilities at these locations have been demolished and removed. NEA's analysis consisted of re-suspending field samples in an aerosolization system they developed. NEA's technique produced both PM-10 (particles with diameters less than 10  $\mu$ ) and Total Suspended Particulate (TSP) data. TSP was considered to be particles with diameters less than 30  $\mu$ .

The PM-10 fraction of the sample was further divided into finer particles less than 2.5  $\mu$  in diameter and coarse particles between 2.5 to 10  $\mu$  in diameter. The coarse, fine, and TSP samples were analyzed by X-ray fluorescence to determine their chemical composition. The NEA results indicated that no appreciable difference in soil composition exists between the particle size groups. The mean arsenic concentrations of the samples varied between 4.7 and 5.3 percent by mass. For this analysis, emissions estimates were made assuming that 5.3 percent of all fugitive dust migrating from the site is arsenic in the form of arsenic trioxide, a major emission from an active smelter.

Fugitive emissions were based on Equation 1 from the 1983 MRI report:

$$E = 380 \frac{(e/11) (s/15) (f/25)}{(PE/50)2} V$$

- E = emission of suspended particulate, that is, particles smaller than 30  $\mu$  in diameter (g/m<sup>2</sup>/year)
- e = soil erodibility for a wide, unsheltered, isolated field with bare, smooth surface  $(kg/m^2/year)$
- s = soil silt content, defined as particles smaller than 75  $\mu$ m as determined by dry sieving through a 200-mesh screen (%)
- f = percent of the time the wind velocity, measured at 0.3 m (1 ft) above the surface, exceeds the nominal wind erosion threshold value of 5.4 m/sec (12 mph)
- V = fractional value reflecting reduction of wind erosion due to vegetative cover (1.0 for bare soil)
- PE = Thornthwaite's Precipitation Evaporative Index used as a measure of average soil moisture.

The equation was derived from field tests of suspended particulate generation during high wind erosion periods. Equation 1 does not consider vehicular activities. Although vehicular generated dust can be substantial, the lack of plant activity at Asarco makes vehicular emissions insignificant.

MRI analyzed the potential for site soils to form a crust during normal conditions. Crusting occurs when soils are allowed to dry. If crusting occurs, a protective layer will form and particulate emissions will be substantially reduced. MRI's analysis showed that site samples, dried at low temperatures, will form a protective crust. Undisturbed, the crusted material will not be a large source of wind-blown dust.

To be conservative, it was assumed that site activities would disturb the soils. This assumption was included in the emissions estimates by calculating the mean soil erodibility for both the disturbed and undisturbed soils reported by MRI. From the MRI report, the average of the mean disturbed and the mean undisturbed soil erodibilities was calculated to be  $4.2 \text{ kg/m}^2/\text{yr}$ . All erodibility values in the report less than  $0.4 \text{ kg/m}^2/\text{yr}$  were set equal to  $0.4 \text{ kg/m}^2/\text{yr}$ . MRI also indicated that the mean silt content was 9.75 percent, and the vegetation cover value V was assumed to be 1.0 for the facility.

The MRI report summarized most of the climatic parameters required for Equation 1. The summer and annual f values, or the frequency of occurrence of winds greater than 5.2 m/s, were determined to be 6.2 percent and 15.33 percent. The summer and annual PE factors used were 6 and 136. The annual value can be found in AP-42. Most of the climatological data was generated by earlier analyses of the wind data.

The emission rates were calculated as:

```
Q (summer) = 40.66 \text{ g/m}^2/\text{quarter}; (2.74 E-7 g/m<sup>2</sup>/sec)
```

Q (annual) = 
$$15.49 \text{ g/m}^2/\text{year}$$
 (2.6 E-8 g/m<sup>2</sup>/sec)

The annual and quarterly emissions rate were multiplied by 0.053 to convert TSP to the arsenic emission rate.

### 5.1.2 SURFACE WATER

Surface water migrates along the routes (pipes and channels) identified in Figure 2-4.

There are two sources of surface water flow: (1) overland runoff and (2) groundwater seepage. Overland runoff occurs during rainfall, while groundwater seepage occurs throughout the year. Thus, groundwater seepage is the only source of flow when it is not raining (base flow), while overland flow and groundwater seepage are the sources of flow when it is raining.

Overland flow enters both the drainage pipes and open channels. Typically, groundwater seepage only enters the open channels, but could also enter cracked drainage pipes. Thus, the source of flow at the open channel stations (SW-1, SW-2, SW-3, SW-4, and SW-13) includes both overland runoff and groundwater seepage. Any additional flow at the remaining stations is primarily overland flow.

Groundwater seepage into cracked drainage pipes would not be a significant source at the Asarco site for two reasons. One reason is that the groundwater table (level) is at a lower elevation than the drainage pipes, such that groundwater would not seep up into a cracked drainage pipe. The other reason is that the site is relatively impermeable to rainfall, so not much groundwater would seep down into a cracked drainage pipe.

Water leaves the surface water system through two routes at the Asarco site: (1) discharges to Commencement Bay through the end of the outfall into Commencement Bay at an elevation of -10 MLLW, and (2) infiltration into the groundwater system. Infiltration can occur in open drainage channels or at cracks in the drainage pipe system. Infiltration is more likely to occur in flat areas where water can penetrate the underlying substrate. The best example of this is in the slag fill area, which is flat and has large cracks for water to flow in.

Fresh water discharged into Commencement Bay rises as a plume to the surface of the marine water because it is less dense and more buoyant than marine water. It then flows along the surface in the direction of tidal currents. During flood tide, water flows to the Tacoma Narrows, where it is thoroughly mixed with upwelling bottom waters. During ebb tide, water flows toward Seattle.

#### 5.1.2.1 Middle Outfall

The middle outfall catchment basin can be separated into two subbasins of different characteristics. The upper subbasin, upgradient of SW-4, has a moderately sloped topography and relatively pervious surface. It is drained primarily by open channels. Groundwater seepage supplies a base flow at SW-4 of about 0.3 cubic ft per second (cfs) (Figure 3-3, Event 2, hour 1).

The lower subbasin, downgradient of SW-4, is relatively flat and impervious (paved). It is drained by drainage pipes. Overland flow supplies additional water to that from SW-4.

The hydrographs in Figure 3-3 show that during base flow the discharge at SW-4 and the outfall (SW-10) are very similar. However, flows are higher at SW-10 than SW-4 during periods of rainfall. These observations indicate that groundwater seepage or infiltration does not have a substantial effect on flow in the lower subbasin. Thus, groundwater seepage and overland flow are sources of surface water in the upper subbasin, while only overland flow supplements surface water discharge in the lower subbasin. Also, nearly all of the water that enters the lower subbasin at SW-4 is discharged at the outfall and does not infiltrate into the groundwater.

#### 5.1.2.2 South Outfall

The south outfall catchment basin can also be separated into two subbasins. The upper and lower subbasins have similar characteristics to those described for the middle outfall. The upper subbasin flows into the lower subbasin at SW-13.

The hydrographs for the south outfall (Figure 3-4) show a different pattern than for the middle outfall. Groundwater seepage supplies a base flow at SW-13 of about 0.1 cfs. During base flow and low tide (Event 2, hour 1), the outfall discharge is only about 0.01 cfs. Thus, there is a loss of about 0.09 cfs in the lower subbasin between SW-13 and the outfall. Because the base flow at SW-12 and SW-13 is nearly equal, this loss of flow occurs between SW-12 and the outfall. This provides evidence for groundwater recharge in this area by pipe leakage into cracks in the slag. The amount of groundwater recharge by this mechanism is likely to be even greater than 0.09 cfs during periods of high flow.

The effect of high tide on the outfall discharge is evident in the hydrographs (Figure 3-4). The high outfall flows at the beginning of Events 1 and 3 are from the release of water that had backed-up in the drainage pipe at high tide. However, there was no outfall flow at the onset of high tide (Event 2, hour 5). It is likely that this back-up of

flow increases the groundwater recharge rate from the additional hydraulic pressure (water level) in the drainage pipe.

Groundwater investigations identified a rise in the water table from high tides (see Section 3.1.2). The maximum rise at a well near the south outfall was to an elevation of about 6.2 ft from the surface of the ground. The elevation of the drainage pipe at SW-11 is about 6 ft, which is at or above the groundwater table. Thus, it is not likely that much, if any, groundwater seepage enters the drainage pipe between SW-12 and SW-11.

#### 5.1.2.3 North Outfall

The north outfall catchment basin is flat and paved. There is no base flow at the north outfall, because it only receives overland flow during periods of rainfall. Water backs up the drainage pipe at very high tides.

An interesting aspect of the hydrographs in Figure 3-5 is the relatively high flows at SW-6 and SW-7. These stations have smaller catchment areas than SW-9 and yet have higher flows. Furthermore, there appears to be a base flow at SW-6 and SW-7.

The source of flow at SW-6 is primarily parking lot runoff. The moderate slope and impervious surface of the parking lot explains the relatively high flows at SW-6. SW-6 may also collect some groundwater seepage, which would explain the presence of base flow. The discharge of steam condensate from the power house explains the base flow at SW-7, while rooftop drainage accounts for much of the flow at SW-7 during periods of rain. Surface water drainage at SW-6, SW-7, and SW-8 is routed to a city outfall located north of the north outfall (Figure 2-4).

#### 5.1.3 GROUNDWATER

The following mechanisms are believed to have caused groundwater contamination at the Asarco site:

- Infiltration of surface water and precipitation through leachable fill materials;
- · Groundwater contact with leachable fill materials;
- Leakage of contaminated wastewaters and subsequent migration into groundwater;
- Spills or leaks of dimethylaniline; and
- Spills or leaks of acid.

The primary source for groundwater contamination is likely the leaching of contaminated granular fill materials. The mechanisms associated with this source are shown schematically on Figure 5-1.

Regardless of source, the hydrogeologic regime of the site, as discussed in Section 3.6, indicates that net groundwater flow is into Commencement Bay. Groundwater therefore acts as a pathway for contamination to migrate off-site. Commencement Bay is the only identified receptor for this migration.

### 5.1.4 GROUNDWATER CONTAMINANT TRANSPORT

Since the contaminant concentrations and groundwater flows change with the tide, groundwater transport of contaminants was estimated using flow and time weighted average concentrations. Time weighted concentrations were obtained from monitoring wells MW-1A2, MW-1B, MW-2A, MW-2B, MW-3A2, and MW-3B.

The estimated average concentrations and mass loading for selected metals are listed in Table 5-1.

Table 5-1. Estimated Average Concentration and Mass Loading for Selected Metals in Groundwater Discharge to Commencement Bay.

	Concentration in $\mu g/L$ Dissolved	n Total	Mass Loading in lb/day Dissolved	Total
Arsenic	7,300	12,000	12	19
Cadmium	21	43	0.035	0.073
Copper	970	3,900	1.6	6.5
Nickel	80	120	0.13	0.20
Selenium	56	60	0.094	0.10
Zinc	2,200	3,300	3.7	5.6
Iron		42,000	•===	70
Manganese	***	1,300		2.3

These estimates are based on flow for the overall site and time weighted averaged concentrations.

Concentrations of contaminants measured immediately offshore from the site are considerably lower indicating substantial dilution takes place as groundwater enters the Bay.

# 5.2 CONTAMINANT PERSISTENCE

# 5.2.1 PRESENCE IN MARINE ENVIRONMENT

#### 5.2.1.1 Introduction

The presence of contaminants in the marine environment may be tested several ways. Each of these indicators measures a different aspect of the potential contamination in the marine environment.

First, portions of the environment (surface and subsurface sediments) may be chemically tested for contaminants. This type of examination determines the absolute presence or absence of the potential contaminant. Although this type of examination gives definitive data on the total concentration of the chemical in question, it does not address whether or not the organisms living in the habitat perceive the presence of that material.

Second, samples from the target areas can be tested for biological toxicity by bioassays. To be meaningful, data from these tests need to be properly controlled, and the organisms in the bioassay need to be appropriate to the material that is tested.

Third, the assemblage of organisms present in the areas can be examined and assessed for potential effects of the whole array of contaminants on the benthic community. This method, while not addressing any one specific organism or toxin, focuses on the overall effect upon the marine benthic community. For an adequate benthos assessment, an uncontaminated reference area should be chosen as a comparative control. This reference area should be as physically similar to the target site as possible.

Fourth, organisms from the environment can be tested for the pressure of chemicals in question. This assessment should involve chemical examination of tissue contaminant loads, development of reproductive indices, and comparisons of morphological structures.

This study used the first three methods to examine the presence and effects of potential contamination in the marine environment. The results of these examinations appear, to some extent, contradictory and unclear. This apparent ambiguity is a result of the differing questions asked by each portion of the analysis.

#### 5.2.2.2 Chemical Determination of Contaminant Presence

The presence of various contaminants in the surficial marine sediments has been well documented in this report. In general, there are trends of decreasing concentrations of the various metals and other contaminants with increasing distance from the site. These trends are not linear: the concentrations near the facility are often quite high, and remain so for some distance then decrease substantially and rapidly.

The form and type of this contamination varies. This variance may be important. High concentrations of metals in marine surficial sediments are particularly difficult to interpret for the size of the particles containing metals. The reason for this is that very fine particles are eaten by sediment-deposit feeding animals and enter the benthic food chains in this manner.

The solubility of most of the contaminants in the marine system is quite low (see the various sections detailing EPTox results). In addition, sediment core chemistry data are unlikely to have substantial biological relevance unless substantial bioturbation occurs. Bioturbation dissolves contaminants, making them accessible to more organisms. Even with bioturbation, sediments below 1 m are rarely going to be encountered by organisms. Thus, buried sediments will have little biological effect as long as the contaminants remain buried and bound into the sediments.

Although the concentration of metals in surficial sediment is quite high in many of the sites, the EPTox values are either below detection limits or quite low. This indicates that the biologically-effective metal concentrations are likely much lower than the values from the surficial chemistry would otherwise indicate. Therefore, although these chemicals persist in the marine sediments, they are unavailable to the organisms due to their low solubility.

This lack of solubility and the lack of any significant toxic effects was particularly noticeable in those benthic samples containing slag. In fact, all slag samples had to be ground into small fragments with a mortar and pestle to remove benthic organisms living in the interstices of the slag. The slag was generally fairly porous, and organisms found the internal cavities and interstices well suited for growth and occupancy. In addition, those slag particles large enough to support the growth of epifauna were covered with substantial growths of epifaunal organisms such as hydroids, bryozoans, and sponges. Although the slag contained substantial amounts of toxic chemicals, these toxins did not appear to be bioavailable to the organisms.

# 5.2.1.3 Biological Effects of Contaminant Presence

#### **Bioassay Evaluation**

The bioassay data indicated that the sediment from some of the sampled stations, particularly T6-1, T10-1, and T12-1, contained chemical characteristics or physical attributes that created a biological effect. There was decreased amphipod and oyster larvae survival at these sites and increased levels of oyster larval abnormalities. Other stations showed less pronounced effects (Table 4-10). Many of these effects were not much different from the effects observed at other, more distant, sites in the greater Commencement Bay region. Because of the variability within bioassay evaluation, however, the level of discrimination of the effects is low. Although the sediment from certain stations obviously had an effect on the bioassay organisms, only the most pronounced effects were detectable. However, because inappropriate test organisms can cause test results to scatter, fine differences between test organisms could not be determined.

#### **Benthos Evaluation**

In general, the data from the benthic analysis indicated high levels of diversity, abundance, and biomass at most of the sampled sites. Historical data of uncontaminated sites with similar sediment particle size distributions (sampled and analyzed with similar methodologies) are difficult to find. Slight differences in analytical methodology (for example, variations in either the sample size, the size of sieving screen, or the number of replicates) can alter the data substantially, making valid comparisons difficult (Holme and McIntyre 1971; Woodin 1974).

Many of the stations in the present study, particularly stations T4-2, T6-3, T8-4, T22-1, and T22-2, contained many more species and individuals per unit area than have been found in the general surveys of the benthos of the Puget Sound region (Lie 1968, 1974; Woodin 1974). Samples T4-2, T6-3, T8-4, T22-1, and T22-2 were exceptionally diverse and rich. In fact all of the stations sampled for this study have more taxa present than Lie (1974) found at any of the 48 stations he sampled throughout the Puget Sound basin.

Some ecological interactions can help determine biologically active contamination. Particularly useful are those interactions involving sediment-ingesting animals, especially mollusks, and those interactions involving toxic-sensitive organisms. Larvae, already discussed in detail, form the array of organisms most sensitive to the toxic effects of contaminated sediments.

Sediment-feeding mollusks and holothuroids eat bacteria and particulate organic material found in the sediment. These deposit-feeders were found at every station except T12-1 (Table 5-2). There was an interesting pattern of abundance of these taxa, since all of the several species involved become less abundant as the proximity to station T12-1 increases. This was due, in part, to the action of contaminated sediment. Either the sediment acted directly upon the sediment-feeding organisms (mostly bivalves) or acted upon the bacteria in the sediment. Since the major component of the fauna at station T12-1 was the deposit-feeding annelid, Notomastus tenuis (which would be eating the same food as the bivalves), some toxic sediment contamination effect directly reduced the abundance of the bivalves. These mollusks and holothuroids were also less abundant at each of the distant transects, T0, and T22. In these cases, the sediment proper was likely unsuitable: at transect T0, it was too hard, at transect T22, it was too silty.

A similar pattern of abundance depression was seen in the examination of the nudibranch predators of the epifaunal hydroids. The hydroids remained relatively abundant throughout the area, but the predators were absent from stations T10-1, T12-1, T11-7, and T16-4. These data were somewhat difficult to interpret because the surficial sediment chemistry indicated relatively low contamination levels at station T11-7 and T16-4.

Although not abundant, the infaunally-feeding gastropods, Cylichnella and Olivella, were found at station T12-1. However, the examination of these animals yielded ambiguous

results. Although they were much more common at station T2-5, their abundance remained consistently low throughout the rest of the stations.

Table 5-2. Contaminant sensitive organisms or interactions.

Station	Sediment Feeding Holothuroids & Mollusks	Infaunal Foram. Feeders	Hydroid Colonies	Nudibranch Hydroid Predators
T2-5	2±4	$93 \pm 73$	11±17	5±9
T3-5	$28 \pm 32$	0	$6 \pm 12$	$12 \pm 15$
T4-2	$100 \pm 96$	2±4	$180 \pm 107$	6±5
T6-3	$50 \pm 41$	0	$12 \pm 20$	$4\pm8$
T8-4	$70 \pm 92$	$8 \pm 12$	$88 \pm 83$	2±4
T10-1	$8 \pm 10$	0	$22 \pm 23$	0
T11-7	0	2±4	$30 \pm 18$	0
T12-1	$8 \pm 12$	$4\pm8$	$18 \pm 23$	0
T16-1	$20 \pm 19$	0	$48 \pm 51$	6±8
T16-4	$14 \pm 28$	0	8±7	0
T22-1	$184 \pm 104$	4±5	$50 \pm 75$	$60 \pm 38$
T22-2	26±25	0	$24 \pm 12$	4±5

Category: Sediment Feeding Mollusks and Holothuroids

Taxon: <u>Bittium sp., Macoma carlottensis, Macoma cf. moesta alaskana,</u>

Macoma elimata, Macoma obliqua, Macoma voldiformis, Macoma sp.,

Tellina nuculoides, Leptosynapta sp. Infaunal Foraminiferan Predators

Taxon: Cylichnella sp., Olivella baetica.

Hydroids

Taxon: Hydroida sp., Obelia sp., Plumulariidae sp., Sertulariidae sp.

Thuiaria sp.
Hydroid Predators

Taxon: Aeolidacea sp., Doto sp., Nudibranchiata sp.

The benthos at each station analyzed for this study represents the result of several interactions. The most important of these interactions are sediment particle size distribution, depth, topographical relief, water current velocity, sediment composition, and toxic contamination. Unfortunately, none of these factors acts in isolation. Furthermore, the gradients within the factors were not clearly linear or independent in their effects. Effects of contaminant persistence were evident at some stations, absent at others, and difficult to assess at the remainder.

### Specific Examples

<u>Pronounced Effects of Contamination - Station T12-1</u>. The low numbers of taxa collected at Station T12-1 reflected contamination effects. Some of the variation seen, however, simply reflected the variation in sediment particle size distribution, so the absolute magnitude of the contamination effects were not clear. Station T12-1 had the lowest per unit wet-weight biomass of any of the samples. Additionally, although it was rich in numbers of organisms, 10,892 animals/m², only 76 taxa were collected there. One species, <u>Notomastus tenuis</u>, accounts for 83 percent of the total. This distribution is a classic example of a community in a pollution-dominated environment.

No Noticeable Benthic Effects of Contamination - Low Sediment Chemical Concentrations - Station T11-7. Some of the low abundance patterns did not reflect contamination effects. Station T11-7 had the lowest density of organisms, 912 animals/m². It also had the lowest arsenic and copper sediment concentrations, and the second lowest lead, zinc, and mercury concentrations. The lowered diversity evident here was clearly a result of sediment particle size distribution.

This station also had the second lowest percentage of gravel, and a relatively high percentage of fine sediments. The sediment was not well-sorted, indicating a relatively high percentage of intermediate-sized particles as well. This assemblage was dominated by epifaunal suspension feeders such as sponges and hydroids. Shrimps, <u>Eualus pusiolus</u>, were also abundant. The low diversity apparent here was likely the result of the sample being dominated by these epifauna, which stabilized and overgrew the substrate resulting in the exclusion of other, particularly infaunal, taxa.

Here, in contrast to station T12-1, the reduced faunal diversity was the result of physical characteristics and biological action not chemical contamination. Many of the taxa collected here (for example, the platyhelminthes of indeterminate species, the polyclads, the kalyptorhynch turbellarians, and the enoplan nemerteans) were active hunting predators. Others such as the anthozoans were passive predators. Even though not diverse, the assemblage sampled at this site had complicated food-webs and a complex array of predators and prey.

No Noticeable Benthic Effects of Contamination - High Sediment Chemical Concentrations - Station T4-2. The highest concentrations of total surficial sediment arsenic(7350 ppm), copper(3025 ppm), lead(6725 ppm), and zinc (17625 ppm) were recorded at station T4-2. This station also had the only significant arsenic EPTox concentrations. The bioassays indicated that the sediment from this site might be having an effect on larvae: the oyster larval bioassay had a mean survival at this site of about 35 percent. Relatively few of those surviving larvae were abnormal, however. Again, the bioassays indicated the sediment might be having a long-term effect on survival since the survival in the amphipod bioassay was significantly depressed. Only about half of those test animals survived. On the basis of these tests, the station should have shown profound effects of toxic contamination.

The benthic data completely refuted such a prediction. The wet-weight biomass was greatest (117 g/m²) of any station sampled. Almost 10,000 animals/m² of 192 taxa were found living in and on the sediments at this station. The bioassay results were unreliable due to the uncontrolled nature of the test, and were further refuted by the abundance of amphipods at this station. While amphipod mortality was high in the bioassay tests, individuals of the amphipod species Tritella pilimana, Ampelisca lobata, Ampelisca agassizi, and Byblis cf. millsi account for about 10 percent of the organisms at this station, and represented 4 of the top 5 arthropod species in abundance. Other amphipod species, Photis sp. Indet., and Ampelisca hancocki, were also commonly found at the site.

The most abundant of these amphipods, <u>Tritella pilimana</u>, which had densities in excess of 750 animals/m<sup>2</sup>, is a caprellid amphipod that lives as epifauna on either the sediment surface or lives on the sessile organisms such as the common Plumulariid hydroids or Anascan bryozoans attached to the sediment particles.

Because they have less contact with contaminants and less effects from contamination, epifaunal organisms are often more abundant than their burrowing counterparts in areas with highly contaminated sediment. The ampeliscan amphipods, the next most abundant arthropods, were found in aggregate densities of over 200 animals/m<sup>2</sup>. They build and live in tubes in the sediment. These tubes are composed of fine sediment particles cemented together. Animals living in the tubes would be in very close contact with the sediments. Amphipods do not have a swimming larval stage, and the females brood their young in a marsupial pouch on their underside. If these sediments were noticeably toxic, it is unlikely that enough juveniles would be produced to offset mortality. The high population density of these species indicated the sediments were not highly toxic.

Other arthropods that do have planktonic larvae showed recruitment of these larvae and recently metamorphosed juveniles into the area. These were free-living crabs in the genera <u>Cancer</u>, and <u>Lophopanopeus</u> and small commensal crabs in the Family Pinnotheridae.

Larvae are generally considered delicate organisms and metal pollution is particularly toxic to them (Strathmann 1987). Thus, they are useful as bioassay organisms. The abundance of arthropod larvae and juveniles in the samples indicated the Station T4-2 area, with its very high sediment metal contaminate concentrations, was not having a noticeable effect on the recruitment of larval arthropods.

Larval echinoderms are also notably sensitive to metals in solution. Within this group, substantial larval recruitment was recorded. Newly settled juvenile sea stars and sea cucumbers were found in moderate densities in these areas (Table 4-10). In fact, the aggregate total of immature forms collected from this site was the highest of any of the stations sampled. Given that larvae were not particularly sampled for, that many from other taxa might not have been enumerated, and that adults of all of these taxa were also enumerated, recruitment occurred with enough regularity to maintain this diverse assemblage of organisms.

Some Noticeable Benthic Effects of Contamination - Variable Sediment Chemical Concentrations - Station T10-1. The pattern of recruitment seen over all of the sampled stations showed a depression in the samples from near the center of the facility. Stations T8-4, T10-1, T11-7, T12-1, in particular, showed few larvae. At station T12-1 this was likely due to the effects of contamination. As stations T11-7 and T8-4 had quite low metal concentrations, the low organism numbers were probably due to normal biological or physical conditions that rendered the station unsuitable for settlement of the particular larvae examined.

Station T10-1 was intermediate in a number of parameters. Although not the highest sampled, the sediment chemical readings were high. This station had about the average number of organisms per square meter, but the number of species was less than some more distant stations. Although the biomass per unit area was relatively high, the wetweight biomass per organism was low. Some of the dominant organisms found at this station, particularly Heteromastus species and Notomastus tenuis, are infaunal sediment deposit feeders typically found in polluted or disturbed sites. However, a number of infaunal organisms found here, especially Compsomyax subdiaphana, Modiolus rectus, and Terebellides stroemi, are characteristically found in fine sediments although not particularly disturbed or polluted ones. The chitons, such as the Ischnochitonidae, which live on pebbles or small rocks, are characteristic of relatively clean areas.

The number of predators was relatively high at this station, with <u>Cerebratulus</u>, the Glycerids, and <u>Harmathoe imbricata</u> especially notable. These animals indicated a diversity of food energy pathways. This diversity creates complicated food-webs and an undisturbed site.

#### Summary

The marine biology/sediment chemistry was conducted in two phases. The intent of the two-phase approach was to gain an understanding of the chemical distribution in the first phase, and then sample for biological effects within different chemical concentration zones in the second phase. The Phase 2 sampling was stratified so that benthic and bioassay samples (and corresponding chemistry data) were collected from areas with high, medium, and low concentrations of metals.

The thought was that the Phase 2 data could be compared in such a way that a "chemical boundary" could be established. At stations where the chemical concentrations exceeded the boundary, a biological effect would be observed. Similarly, at stations where the chemical concentrations were below the boundary, no biological effect would be observed.

Due to a complex interaction between physical characteristics, chemical concentrations, bioavailability of contaminants, and the adequacy of bioassay test organisms, it was not possible to establish chemistry boundaries. Inconsistencies and variability were prevalent in two types of comparisons that we attempted to make. The first type compared results of biological effects tests (benthos and bioassays) at the same stations. It was not uncommon to find inconsistencies between the tests (for example, diverse and abundant

benthic populations and poor bioassay survival) at some of the stations. The second type of comparison investigated differences in biological effects test results between stations that had similar chemical concentrations. This type of comparison commonly showed variability between the results. For example, one station had good bioassay survival while another had poor survival, yet both had similar chemical concentrations. There is no single clear explanation for the inconsistency and variability. Undoubtedly, the factors mentioned above (physical characteristics, bioavailability of contaminants, and adequacy of bioassay test organisms) all contribute to the explanation.

Relevant physical, chemical, and biological parameters are summarized in Table 5-3. Data from sediment cores were not included in this table because they were unlikely to have contained biologically relevant data. Surficial sediment chemistry information, however, is pertinent to organisms living on or within the benthos. A number of relatively deeply burrowing organisms were encountered at some of the stations (for example, Solen sicarius, the jackknife clam, and the ghost shrimp, Callianassa species). Although these animals can burrow effectively into the sediment, it is unlikely they would go much below 0.5 m in any situation. No larger bivalves or other burrowing animals were sampled. Their absence might possibly indicate sediment toxicity, but given the array of organisms sampled at most of these stations, it represented either lack of suitable sediment or insufficient sampling. Thus, the chemistry data obtained from the surficial sediments was the most pertinent to the organisms.

Because of the overlying sediment and the low solubility of the contaminants, deeply buried material was unlikely to have leached much toxic material into the overlying water. The surficial sediments would likely retain the leachate, and this is where most of the biological effects would be noticed. Given the array of organisms found in these areas, it is unlikely that the continued leaching of soluble material at the present rate will have any effects other than those measured in this study.

The relationships of the organisms to the sediments and the contaminants was not clear. A number of taxa, particularly mollusks, were likely affected by the contamination, and their distributions seem to be altered somewhat (Table 5-2). But the overall organism distribution was clearly not significantly influenced by any of the contaminants (Table 5-4). A multifactor correlation analysis was done using all possible combinations of a number of general assemblage factors. These factors were biomass, the number of organisms, the number of taxa, and a number of station characteristics such as total metals concentration for most of the major contaminants, the amount of gravel and fine sediment, and the EPTox levels for arsenic and lead. Hydrocarbon abundances were not included in these analyses since they were not detected at enough benthos stations to make the correlations significant or meaningful (Table 5-4).

The number of organisms was positively correlated with the amount of gravel or coarse sediment in the samples. The biomass was positively correlated with the arsenic EPTox level of the sample. Otherwise, there were no statistically significant correlations with any station physical or chemical parameter. Although the correlation between biomass and arsenic, EPTox level was notable. There was no correlation between gravel and the arsenic EPTox level, thus the arsenic EPTox level did not depend upon the gravel.

Table 5-3. Summary of station properties, physical and chemical.

			PHYSICAL							CHEMICAL					
			COARSE	MEDIUM		T	OTAL METAL	CONCENTRA	TIONS			EP TOX		HYDROCAF	RBONS
	DEPTH	GRAVEL	SAND	SAND	FINES	As	Cu	Рb	Zn	Hg	As	Pb	Cd	LPAH	HPAH
STA.	<u>(ft)</u>	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(ppm)	(ppb)	(ppm)	(ppm)	(ppm)	(ppb)	(ppb)
T00-2	<10	NA	NA	NA	NA	14	30	24	95	60	ND	ND	ND	ND	NE
T00-3	105	NA	NA	NA	NA	85	80	88	135	225	ND	ND	ND	ND	, NE
T01-1	83	35.5	12.4	28.7	23.5	19	50	33	275	68	ND	ND	ND	ND	NE
102-1	77	50.5	7.1	24.5	17.7	30	120	65	735	110	ND	ND	ND	ND	NE
102-5	310	7.4	0.5	69.7	22.3	27	23	35	50	91	ND	ND	ND	ND	: NE
103-2	135	2.3	3.3	79.7	14.4	455	244	488	140	2275	ND	ND	ND	ND	; NC
T03-4	250	6.4	9.7	61.5	22.4	2378	998	2550	260	11250	ND	ND	ND	ND	· NE
T03-5	310	2.3	3.7	66.0	28.0	1940	793	1565	280	6175	ND	0.020	ND	ND	NC
T03-6	370	4.8	5.3	70.8	19.1	1130	468	845	250	2725	ND	ND	ND	ND	NE
T04-2	165	47.0	21.9	19.1	8.4	7350	3025	6725	170	17625	0.830	ND	ND	ND	NC
<b>105-0</b>	35	3.6	4.6	47.3	43.5	86	805	243	340	1200	ND	0.033	ND	ND	14950
106-1	90	31.8	25.8	35.3	7.3	9150	3375	9975	160	21800	ND	0.020	ND	ND	NC
ハ100-1 1 106-3 ハ108-4	160	3.7	5.9	66.5	23.1	2550	1203	2223	250	5800	ND	ND	ND	ND	NE
<b>万 108-4</b>	105	12.5	2.9	41.0	40.5	55	70	62	190	143	ND	0.020	ND	ND	NC
110-1	43	18.9	10.3	47.6	22.6	590	1873	860	1800	1000	ND	0.100	ND	1870	11650
T10-2	60	5.4	2.6	68.4	22.6	95	152	77	600	176	ND	0.067	ND	2480	2570
T11-7	150	0.1	0.3	72.1	27.0	13	21	28	60	55	ND	ND	ND	ND	NC
T12-1	30	43.0	7.6	14.8	35.1	2355	8200	3275	5600	3975	ND	0.520	0.025	53410	86180
T16-1	70	0.5	0.5	32.6	65.1	48	141	44	220	81	ND	0.020	ND	ND	NC
T16-4	195	0.0	0.1	43.7	54.7	16	21	19	70	53	ND	0.020	ND	2600	2990
T18-2	73	0.7	0.6	34.1	63.1	33	65	<b>3</b> 5	120	56	ND	ND	ND	ND	N
T22-1	30	NA	NA	NA	NA	49	138	117	300	145	ND	ND	0.003	ND	1710
122-2	84	NA	NA	NA	NA	46	104	620	340	185	ND	ND	0.005	ND	230

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 Gravel
 2.0-1.0 mm

 Coarse Sand
 1.0-0.5 mm

 Medium Sand
 0.5-0.25 mm

 Fines
 <0.25 mm</td>

ND = not detected NA = no data

Table 5-3. Summary of station properties, biological.

						BENTHOS				BIOASSAY	
				BIOMASS F	ER	D	IVERSITY		OYSTER		AMPHIPOD
	DEPTH	NUM	4BER OF	STATION	ORGANISM	SIMPSON	SHANNON	J	NORMAL	SURVIVAL	SURVIVAL
STATION	(ft)	TAXA	ORGANISMS	(g/sq. m.)	(mg)		-WIENER	(EVENESS)	(%)	(%)	(%)
100-2	<10	NA	NA	NA	NA	NA	NA	NA	70.5	33.8	93.0
100-3	105	NA	NA	NA	NA	NA	NA	NA	77.0	24.9	71.0
T01-1	83	NA	NA	NA	NA	NA	NA	NA	70.9	24.5	94.0
T02-1	77	NA	NA	NA	NA	NA	NA	NA	58.5	21.1	96.0
T02-5	310	102	930	31.2	33.5	0.042 + 0.009	3.333 + 0.141	0.721	96.0	41.2	81.0
103-2	135	NA	NA	NA	NA	NA T	NA T	NA	97.9	50.7	86.3
T03-4	250	NA	NA	NA	NA	NA	NA	NA	89.6	25.3	86.0
T03-5	310	143	1814	62.4	34.4	0.044 + 0.013	3.415 + 0.351	0.688	71.1	21.5	61.3
T03-6	370	NA	NA	NA	NA	NA	NA	NA	96.3	48.3	96.3
104-2	165	192	9860	117.7	11.9	0.102 + 0.018	3.153 + 0.101	0.6	86.8	27.3	51.0
T05-0	35	NA	NA	NA.	NA	NA	· NA	NA	69.7	10.6	91.0
T06-1	90	NA	NA	NA	NA	NA	NA	NA	0.0	0.0	3.0
106-3	160	205	5146	80.2	15.6	0.053 + 0.028	3.759 + 0.242	0.706	73.5	33.8	78.0
T08-4	105	208	5418	91.3	16.9	0.03 + 0.004	3.967 + 0.073	0.743	94.9	31.6	83.0
T10-1	43	112	5428	62.1	11.4	0.072 + 0.011	3.153 + 0.165	0.668	22.5	6.8	86.0
T10-2	60	NA	NA	NA	NA	NA	NA A	NA	63.1	13.0	93.0
T11-7	150	90	912	36.2	39.7	0.097 + 0.032	2.775 + 0.386	0.617	84.9	50.2	96.0
T12-1	30	76	10892	13.6	1.2	0.523 + 0.302	1.388 + 0.853	0.320	16.5	7.2	38.0
T16-1	70	143	4852	47.7	9.8	0.080 + 0.012	3.311 + 0.107	0.667	91.7	12.0	95.0
T16-4	195	107	1322	22.5	17	0.060 + 0.026	3.329 + 0.267	0.712	82.2	8.3	83.0
T18-2	73	NA	NA	NA	NA	NA	NA T	NA	69.3	17.3	86.0
T22-1	30	194	12682	68.9	5.4	0.065 + 0.021	3.512 + 0.205	0.667	79.0	20.6	91.0
T22-2	84	184	9982	94.9	9.5	0.068 + 0.011	3.448 + 0.081	0.661	89.3	40.5	75.0

NA = no data

Table 5-4. Correlation between sediment factors.

	# Taxa	# Org.	Biomass	Biom/Org	As	Cu	Pb	Hg	Zn
# Таха		0.4248 (12) 0.1686	0.8729 (12) 0.0002	-0.2924 (12) 0.3564	(12)	(12)	0.1880 (12) 0.5584	(12)	0.2975 (12) 0.3477
# Org.	NS		0.4140 (12) 0.1809	-0.8240 (12) 0.0010	(12)	(12)	0.4266 (12) 0.1666	(12)	0.2709 (12) 0.3943
Biomass	<0.001	NS		-0.2009 (12) 0.5313	0.4801 (12) 0.1142	(12)	0.4232 (12) 0.1702	(12)	0.5213 (12) 0.0822
Biom/Org	NS	0.0010	NS		-0.1759 (12) 0.5846	(12)	-0.2770 (12) 0.3834	(12)	-0.0947 (12) 0.7698
As	NS	NS	NS	NS		0.4923 (12) 0.1040	0.9832 (12) 0.0000	(12)	0.9910 (12) 0.0000
Cu	NS	NS	NS	NS	NS		0.6228 (12) 0.0305	(12)	0.3984 (12) 0.1996
Pb	NS	NS	NS	NS	<0.001	< 0.05		0.2903 (12) 0.3600	0.9554 (12) 0.0000
Hg	NS	NS	NS	NS	NS	<0.001	NS		0.0325 (12) 0.9201
Zn	NS	NS	NS	NS	<0.001	NS	<0.001	NS	
Gravel	NS	<0.001	NS	NS	<0.05	<0.001	<0.001	NS	< 0.05
Fines	NS	NS	NS	NS	NS	NS	NS	NS	NS
As-EpTox	NS	NS ·	< 0.05	NS	<0.001	NS	< 0.001	NS	0.0001
Pb-EpTox	NS	NS	NS	NS	NS	< 0.05	NS	<0.001	NS

NS = Non-significant

CELLS: Correlation coefficient

(Sample size) Probability

Table 5-4. Correlation between sediment factors.

	Gravel	Fines	As-EpTox	Pb-EpTox
# Таха	0.0360	-0.1605	0.3902	-0.4897
	(10)	(10)	(10)	(10)
	0.9213	0.6577	0.2649	0.1508
# Org.	0.8883	-0.2060	0.5125	0.4869
	(10)	(10)	(10)	(10)
	0.0006	0.5681	0.1299	0.1535
Biomass	0.2844	-0.4589	0.6546	-0.4600
	(10)	(10)	(10)	(10)
	0.4258	0.1822	0.0400	0.1809
Biom/Org	-0.5832	-0.2440	-0.2031	-0.3516
	(10)	(10)	(10)	(10)
	0.0768	0.0660	0.5735	0.3191
As	0.7372	-0.6012	0.8887	0.2761
	(10)	(10)	(12)	(12)
	0.0150	0.6600	0.0001	0.3851
Cu	0.8126	-0.2135	0.2292	0.7993
	(10)	(10)	(12)	(12)
	0.0043	0.5536	0.4736	0.0018
Pb	0.8291	-0.5821	0.8519	0.3827
	(10)	(10)	(12)	(12)
	0.0030	0.0775	0.0004	0.2195
Hg	0.6112	-0.0118	-0.1203	0.7551
	(10)	(10)	(12)	(12)
	0.0605	0.9742	0.7096	0.0045
Zn	0.6606	-0.6056	0.8922	0.1754
	(10)	(10)	(12)	(12)
	0.0376	0.0635	0.0001	0.5855
Gravel		-0.4624 (10) 0.1785	0.6656 (10) 0.0357	0.5755 (10) 0.0817
Fines	NS		-0.5065 (10) 0.1352	-0.1937 (10) 0.5917
As-EpTox	NS	NS		0.0823 (12) 0.7991
Pb-EpTox	NS	NS	NS	

These analyses indicated the relationships between the organisms, sediments, and the contaminants was complicated. Station T12-1 was substantially polluted with metallic and hydrocarbon contaminants. Examination of the cluster analysis of the benthos showed that the station most like T12-1 was T10-1 (Figure 4-88). On this basis, it would seem reasonable to infer that T10-1 was similarly contaminated. Although T10-1 had relatively high levels of contaminants, it was not as contaminated as station T4-2, which was ecologically diverse, and had few apparent contaminant effects.

Stations T4-2, T6-3, and T8-4 were clustered in the analysis (Figure 4-88). They had dissimilar bioassay results and chemical contamination. Their sediment particle size distributions were similar, however. And they occupied a similar depth range. It appears that these communities were not structured by the contamination, but rather by the normal-ecological processes in the area.

Normal ecological effects were difficult to separate from the contamination effects. Station T11-7 was similar, in many regards, to station T12-1. It had low organism diversity and numbers. Yet Station T11-7 is one of the cleanest stations in the whole array with regard to chemical contamination, having chemical concentrations substantially below those of the distant reference sites (Table 5-4).

Contaminate effects appeared limited spatially to those sites near shore, particularly T12-1 and T10-1. Some more distant stations (for example, Station 16-4) were not clearly dominated by contamination effects.

Stations in the area of slag deposition showed a marine benthic community altered substantially from that found normally on the native mixture of sand and silt. This community was dominated by organisms more typically found in coarse sediment or cobble-substrate communities. The assemblage found at Stations T4-2, T8-4 and T6-3 was rich and diverse, with good larval recruitment, and complex ecological interactions. This assemblage appeared normal, with little or no effect of the substantial metal concentrations present in the slag.

One aspect of contaminant persistence that this RI did not address was the presence/absence of contaminants of concern in marine organisms farther up the food chain from benthic biotas. Given the apparent ability of benthic communities to thrive at stations that had high chemical concentrations, the issue of contaminants being passed along the food chain becomes an important one.

Concentrations of inorganic substances were reported for muscle tissue of English sole captured along the Ruston shoreline in the Commencement Bay Nearshore/Tideflats RI (Tetra Tech 1985). Sole were caught in trawl from three stations along Ruston: north of the smelter site, immediately in front of the smelter site, and to the south of the smelter site. Mean values from these sites combined were reported as follows:

<u>Analyte</u>	Ruston (ppm)	Carr Inlet Reference
Arsenic	6.3	7.9
Cadmium	0.01	0.02
Chromium	0.20	0.19
Copper	0.096	0.038
Lead	0.16	0.22
Nickel	0.148	0.115
Silver	0.002	0.008
Zinc	3.9	3.7
Mercury	0.052	0.055

Of these analytes, only copper was significantly higher (P<0.05) than the Carr Inlet reference area.

English sole were also examined for hepatic lesion prevalence. There was no significant prevalence in fish from the trawls immediately offshore of the smelter site and to the north of the smelter site. There was significant lesion prevalence in sole captured in the trawl to the south of the plant site (Tetra Tech 1985).

Crab muscle tissue from the Ruston shoreline area was not collected for inorganic concentration analysis (Tetra Tech 1985).

### 5.3 CONTAMINANT MIGRATION

### 5.3.1 AIR QUALITY

The "Guideline On Air Quality Models (Revised)" recommends the Industrial Source Complex models (ISCST and ISCLT) for modeling fugitive dust sources (EPA 1986). The "ST" and "LT" in ISCST and ISCLT stand for the short-term and long-term versions of the same model. ISCLT required a frequency distribution of meteorological data to calculate annual impacts. The ISCST model requires hourly meteorological data and calculates ambient concentrations and particle deposition for point, area, and volume sources for 8- and 24-hr values. ISC calculates deposition through user-specified gravitational settling velocities and particle reflection coefficients. Because the models do not calculate impacts at receptors located above emission height, flat terrain was assumed. The model does not calculate particle deposition velocities.

Deposition velocity has been defined as the deposition flux per the pollutant concentration at some reference point. Near the surface, the atmosphere is composed of turbulent and quasi-laminar layers that control the deposition process. Depending upon particle size, particle density, and frictional effects present at the surface, particle deposition can be greater than that defined by gravitational settling alone.

FDM was designed to take a more realistic view of particle settling by calculating deposition velocity. The model uses computer codes developed by the California Air Resources Board based on the work of George Sehmel of Battelle Pacific Northwest

Laboratory. The model has performed well in previous modeling comparison studies and is an improvement over the ISC models. Much like ISC, FDM will calculate ambient concentrations and depositions of short- and long-term averages for point, volume, and area sources. The model assumes flat terrain.

Neither model takes into account the effects of terrain. However, Asarco was modeled as a collection of area sources which emits dust at ground level. Therefore, the center of the plume will remain at the surface producing maximum ground level fugitive dust impacts. The no terrain approach is considered to be a reasonable estimate of fugitive dust impacts.

#### 5.3.1.1 Sources

TRC's approach focused on the major sources located closest to off-site receptors free of wind barriers. Three general areas were selected to represent plant emission sources. The area of greatest concern is the site stabilization area which extends from the Herreshoff roaster bag house to the stack area and the area extending southward to the tavern site. The area is within the plant fence and generally free of all vegetation. The area was divided into four area sources, depicted in Figure 5-2 as sources 1 through 4. ISC requires that square area sources are defined for model input. Although, Figure 5-2 exaggerates the plant boundary line to the Ruston town limits, the plant boundary corresponds approximately with sources 1, 2, and 3.

Area sources 5 and 6 include the area from the Bennet Street plant boundary and the area around these locations: main offices; refinery 1, 2, and 3; parking lots; and the power house. The area is closest to the Ruston school site and residents along Bennet Street. The area is not expected to produce a large quantity of emissions since it is partially paved.

Sources 7 and 8 encompass the area south of the fine ore storage areas close to the sulfur dioxide plant. This area is open to the wind and is mostly paved although partially covered with soil. The sulfur dioxide plant and facilities located on the land side of the plant will not provide significant resistance to soil migration because the process equipment is not enclosed. The equipment has been sold and was being dismantled. The source definition also allows the placement of receptors on plant property. This is of greatest importance for the ISC models which will not calculate deposition and concentrations for receptors located within 1 m of a source.

The areas east of sources 5 and 6 and north of sources 4 and 7 are not expected to produce significant impacts in the study area. This is based on the assumption that plant structures will act as barriers to the wind and confine the impact of this area to the plant. Complex cavity circulation is beyond the capabilities of both models. All sources are modeled as ground-level sources.

Particle composition and size distribution data were incorporated in model input. Based on the methodology established in the ISC users guide, particle characteristics were determined for arsenic trioxide, which was chosen to represent all arsenic species

migrating from the site (see Table 5-5). The four values presented in the table are these: (1) mean particle diameter, (2) the fraction of total mass composing each individual particle size class, (3) velocity with which a particle will settle due to the force gravity, and (4) the tendency of the particle to stop, reflection coefficient (r.c.) = 0.0, when it reaches the surface or to continue moving, r.c. = 1.0. The particles were assumed to have the same density as arsenic trioxide,  $3.8 \text{ g/cm}^3$ .

Table 5-5. Particle characteristics used in the modeling.

Category	1	2	3
Mean diameter (μm)	1.57	6.92	21.54
Mass fraction Settling velocity (m/s)	0.0963 0.0003	0.4408 0.0054	0.4629 0.0525
Reflection coefficient	1.0	0.84	0.61

Source: TRC Environmental Consultants, Inc.

# 5.3.1.2 Receptors

A review of the wind roses for 1982, 1983, and 1984 indicates that southwest and northeast wind directions dominate at the plant location. Northeast winds dominate during the summer when winds are lighter and mean monthly precipitation averages less than one inch. Higher velocity southwest winds predominate during the winter months, producing the wet conditions the Pacific Northwest is known for. The receptor array was designed to account for both wind conditions and to cover the residential areas of Ruston and Tacoma. Receptors were placed at 100 m intervals from the source boundaries west to Pearl Street and south to North 46th Street. All ambient monitors were included in the receptor grid. A number of receptor points were also placed over Commencement Bay and on the Asarco site to define impacts for these areas. The total number of receptors was 147 for FDM and 144 for ISC. More receptors were included in the FDM model runs because FDM permits placing receptors within or near an area source.

ISCLT was run using the STAR frequency distributions generated from the Asarco/SeaTac meteorological data sets from the years January 1982 through June 1985. A STAR frequency distribution plots the frequency of winds from the sixteen cardinal wind directions for six wind speed classes and six stability types. The model was run in a regulatory mode for both deposition and concentration calculations. When concentrations were calculated, no particle deposition was assumed. Thus, concentration estimates were conservative. The concentrations and deposition for the maximum impact year was plotted for easy analysis.

The FDM is specifically designed to calculate deposition of particulate matter. The model calculates total deposition based on the gravitational settling and depositional velocities. The models were run using input parameters similar to ISCLT. However, particle deposition was not assumed during the concentration determination.

The short-term analysis focused on high wind events during the driest periods of the year. June, July, and August of 1982 through 1984 were modeled with ISCST for periods with higher winds and neutral stabilities. The year 1985 was not modeled since only June meteorological data were available. A variable emissions option in ISCST was used. It allowed half of the short-term emission rates during neutral stabilities and wind between 3.1 and 5.2 m/sec and the full short-term emission rates for periods with winds greater than 5.2 m/sec. This method allows ISCST to identify the periods when high emissions and impacts are expected. Since FDM is an episodic model, only the days identified by ISCST were modeled with FDM.

Deposition modeling was done identically to concentration modeling, except particle size data were included. Unlike ISC, FDM calculates deposition and settling velocities for each of the averaging periods under review. Annual and 24-hr deposition were estimated for both models.

#### 5.3.1.3 Results

Contour maps (isopleths) of concentration and deposition are presented in Figures 5-3 to 5-12. Isopleth diagrams are a convenient means of displaying the spatial distribution of pollutant concentrations. The diagrams indicate that ISC and FDM predicted maximum impacts slightly at different locations. Figures 5-3, 5-4, 5-9, and 5-10 depict the annual concentration and deposition estimates. The 1983 meteorological data produced the highest annual impacts for both models. ISCLT favored the area of plant demolition as the location of maximum annual concentration and deposition. FDM showed similar tendencies although the maximum impact point was more sharply defined, with a stronger concentration gradient and was located south and east of the ISCLT maximum. This difference is due to the technique used in FDM for the treatment of each area source as five line sources compared to ISC, which considers a square-area source. Table 5-6 is a list of the maximum predicted annual and short-term impacts on and off the site.

Figures 5-5, 5-6, 5-9, and 5-12 depict the maximum short-term predicted concentration and deposition estimates for both models. Maximum impacts occurred for the 1984 meteorological data. ISCST consistently predicted the maximum 8- and 24-hr impacts at receptors within the plant boundary downwind of the sources during southwest winds. Secondary maximums occur along the southwestern corners of the plant close to the Ruston school and the tavern site. The deposition and concentration gradients are greatest closest to the plant boundaries. In no case, are the ISC results above the Washington Department of Ecology arsenic community exposure standards of 0.3 and 2.0  $\mu g/m^3$  for the annual and the 24-hr periods.

FDM predicted maximum impacts to occur in and around the area of the cooling pond, Gallagher Way and Dock Street. Maximum 24-hr impacts are depicted as approximately  $1.5 \ \mu g/m^3$  and  $2.2 \ \mu g/m^3$  for an 8-hr average. This area, however, is not indicative of areas where impacts will typically occur for local residents. The Ruston school and the tavern site are areas where local residents will be exposed to the impact of the smelter. Off-site impacts of 1.0 and  $0.4 \ \mu g/m^3$  respectively can be expected for the 24-hr period at these locations. Deposition estimates from FDM indicated that maximum off-site deposition will be less than  $0.1 \ g/m^2$  arsenic per year at the property line west of the Asarco stack. Total deposition of TSP at this receptor is estimated at  $1.3 \ g/m^2$ .

Table 5-6. Asarco arsenic concentration and deposition.

	Conc	Maximum Concentration $(\mu g/m^3)$		num tion <sup>2</sup> )
	ISCLT	FDM	ISCLT	FDM
ANNUAL				
on site off site	0.13 0.13	0.3 0.2	0.0008 0.0008	0.12 0.07
24 HOUR				
on site off site	0.98 0.59	2.8 1.5	0.0001 0.0001	0.0061 0.0036
8 HOUR				
on site off site	1.1 0.8	3.8 2.2		

Source: TRC Environmental Consultants, Inc.

Concentrations of other elements can be calculated from the concentrations presented. To do so, it must be assumed that the deposition rates of TSP, as previously defined for the arsenic modeling, are applicable for the oxides of copper, lead, and cadmium. The concentrations of copper, lead, and cadmium can be determined by multiplying the arsenic concentrations the following factors:

Metal	Factor
antimony	0.12
cadmium	0.01
chromium	0.02

copper	1.00
lead	0.90
nickel	0.02

The conversion factors are simply the ratios of the concentrations of these metals to the arsenic concentration of the soils as determined by the NEA analysis.

# 5.3.1.4 0.5 Kilometer Analysis

Further analysis refined the analysis of the impact of the facility on residents in Ruston. Most people do not live in the immediate vicinity of the plant and, therefore, will not be exposed to impacts at the property line. To determine a more realistic community exposure to suspended and deposited arsenic trioxide, ISC and FDM were run with a receptor grid 0.5 km from the center of Source 4. Nineteen receptors were placed on radials from 140 degrees to 320 degrees at 10-degree intervals. Receptors on the 340-degree radial will be located slightly north of the Ruston school. The receptors will follow Winnifred Street, and cross Baltimore and Orchard Streets more than 100 m south of the plant boundary. At that distance, ISC and FDM give comparable results. The results of modeling at these locations are listed in Table 5-7.

#### 5.3.1.5 Conclusions

TRC performed a modeling analysis to determine the air quality impacts of the existing Asarco smelter on the residents of Ruston and Tacoma. Ambient concentrations and total deposition of arsenic and other metals were estimated using the meteorlogic data collected for the years January 1982 through June 1985. Maximum impacts were predicted for fugitive emissions generated at the site or at the property line in the demolition area. The ambient impact of wind-blown dust from the site decreases rapidly with distance from the site.

For a comparison of modeling data to ambient arsenic monitoring data recorded at two plant boundary locations, Asarco low-volume sampling data were compared to the worst-case annual and short-term model predictions listed in Table 5-8. Ambient monitoring data for 1988, complete though August 25, 1988, represents the only data from a period when site operation or demolition was not occurring.

Table 5-8 indicates that both modeling techniques performed reasonably well for the worst-case annual averages predicted for 1983 meteorological data. Of all the values, only the FDM predictions for the tavern site show poor agreement with ambient data. This indicates the sensitivity of the model to source size, since sources 1 and 2, closest to the tavern site, are the smallest area sources defined for Asarco study. The tavern site data will also be impacted by local sources of particulate matter, which will add to the background levels of arsenic not added to these results. Off-site open lots and roadways abound in the immediate area.

Table 5-7. Annual and 24-hour concentration and deposition at 0.5 km.

Annual Arsenic Concentration and Deposition								
	Concentration		Deposition	Deposition				
Direction	ISC	FDM	ISC	FDM				
From Site in Degrees	$(\mu g/m^3)$		(g/m <sup>2</sup>	)				
320	0.043	0.026	0.0003	0.007				
310	0.031	0.023	0.0002	0.006				
300	0.027	0.021	0.0002	0.007				
290	0.027	0.021	0.0002	0.007				
280	0.026	0.022	0.0002	0.008				
270	0.027	0.022	0.0002	0.009				
260	0.027	0.023	0.0002	0.008				
250	0.027	0.022	0.0002	0.006				
240	0.028	0.022	0.0002	0.006				
230	0.030	0.024	0.0002	0.006				
220	0.033	0.025	0.0003	0.007				
210	0.036	0.026	0.0003	800.0				
200	0.042	0.025	0.0003	0.010				
190	0.043	0.026	0.0003	0.006				
180	0.038	0.026	0.0003	0.006				
170	0.037	0.029	0.0002	0.006				
160	0.040	0.033	0.0003	0.008				
150	0.048	0.042	0.0003	0.008				
140	0.064	0.063	0.0003	0.014				
	24-Hour Concentration	s and Deposition	IS.					
320	0.03	0.22	>.00001	0.0002				
310	0.02	0.17	>.00001	0.0002				
300	0.03	0.05	>.00001	0.0001				
290	0.03	0.05	>.00001	0.0001				
280	0.07	0.07	0.00001	0.0001				
270	0.11	0.11	0.00001	0.0002				
260	0.15	0.16	0.00002	0.0003				
250	0.18	0.23	0.00002	0.0004				
240	0.19	0.25	0.00002	0.0005				
230	0.16	0.24	0.00002	0.0005				
220	0.19	0.27	0.00002	0.0006				
210	0.25	0.31	0.00003	0.0006				
200	0.33	0.32	0.00003	0.0007				
190	0.37	0.21	0.0004	0.0005				
180	0.24	0.17	0.00002	0.0003				
170	0.23	0.31	0.00003	0.0006				
160	0.29	0.53	0.00004	0.0001				
150	0.34	0.75	0.00004	0.0016				
140	0.47	0.95	0.00006	0.0022				

Source: TRC Environmental Consultants, Inc.

Table 5-8. Ambient monitoring data and model comparison.

1988 ANNUAL DATA (μg/m3)						
SITE	MEASURE	ISCLT	FDM			
TAVERN SITE	0.09	0.07	0.04			
ASARCO PARKING	0.09	0.07 TTY-FOUR HOU	0.07 R DATA			
		/m3)				
TAVERN SITE	0.7	0.5	0.4			
ASARCO PARKING	0.6	0.3	0.9			

Source: TRC Environmental Consultants, Inc.

Twenty-four hour predictions for 1984 show a much wider variation of results when compared to the annual values. ISCST underestimated ambient concentrations for both receptors. FDM results indicate much of the same tendencies displayed for the annual predictions. Underestimations at the tavern site are slight, less than 30 percent. FDM overestimated the impact at the Asarco parking site by less than a factor of two. The Asarco ambient data also indicates that peak wind-blown dust events can occur during periods other than summer months. This analysis also demonstrates the difficulty of comparing measured values with predictions generated for different modeling years.

The Asarco analysis was done to estimate the amount of wind-blown dust created at the site and moving off-site to populated areas surrounding the plant. The analysis is conservative by assuming the site to be open and unpaved, creating high emission rates from the plant. The potential for soil erosion was assumed to represent a site more active than the low levels of activity occurring at the Asarco facility. The degree of conservatism is necessary to account for the uncertainties of the analysis due to the model's inability to account for terrain for ground-based releases. In addition, the analysis was done for current site conditions, using past on-site meteorologic data.

The analysis presents a reasonable estimate of conditions on- and off-site. The distribution of impacts represented by the isopleth diagrams are a good indication of wind-blown dust effects. Ambient impacts of arsenic are expected to be highest on site and not expected to exceed ambient guidelines off site.

#### 5.3.2 SURFACE WATER

Contaminant migration follows the routes of migration discussed in Section 5.1.2. Metals are the contaminants of concern in surface water.

Arsenic and copper concentrations at the background sites (SW-1 and SW-2) are elevated above that in average residential runoff. Metal concentrations in runoff from residential communities in metropolitan Seattle (Stewart et al. 1988) were compared to concentrations at the background stations. The average total arsenic concentration at the background stations was nine times higher than Seattle's residential runoff, while copper was six times higher. The concentration of all other metals were not elevated at the background stations.

The predominant source of metals to surface waters discharging to Commencement Bay is located in the central plant area. Overland runoff from this area enters the drainage system in the lower subbasins of the middle and south outfall. This runoff would have to be highly contaminated to account for the dramatic increase in concentrations from the upper subbasins to the lower subbasins. The increase in concentration was different for each metal, as discussed in Section 4.2, and reflects the relative concentration in runoff and pipe sediment from the central plant area.

Significant quantities of metals are migrating from the surface water to the groundwater in the south outfall lower subbasin. The flow of this groundwater recharge can be estimated at 90 percent of the flow at SW-12 (see Section 5.1.2). The annual loading of metals from groundwater recharge is estimated to be about two-thirds of the south outfall loadings presented in Table 4-3. This assumes metals concentrations equal to the average of mean values at SW-12 and the outfall (SW-11).

The migration of metals from the outfalls in marine waters was not studied. The direction and distance of migration would depend on nearshore surface currents. The distance of migration would vary for each metal, depending on each metal's settling rates. Particulate metals would settle faster than dissolved metals. Thus, metals like lead and mercury that are nearly all particulate would not migrate far in marine waters, relative to metals like zinc, nickel and cadmium that are nearly all dissolved.

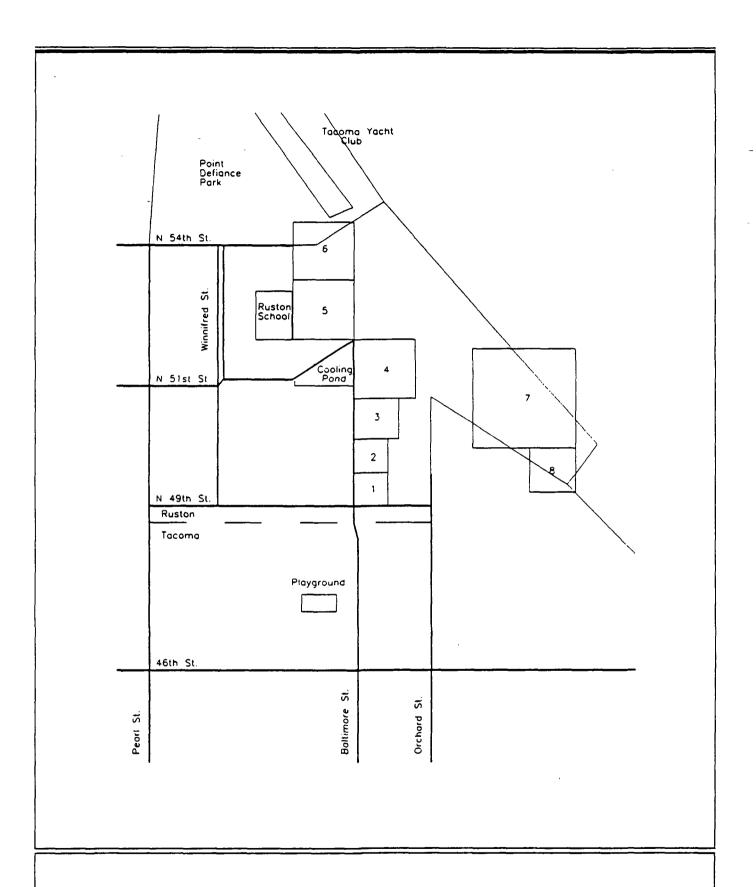
Metal concentrations in the outfall discharge would be diluted as it is mixed with marine water. A simple outfall plume model was used to predict the dilution rate of the discharge as it rises to the surface. The dilution rate of the middle outfall was predicted to range from 6.5 (during low tide and a high flow of 2.5 cfs) to 35 (during high tide and a low flow of 0.5 cfs). Dilution rates at the other outfalls would be higher than the middle outfall because of lower discharge flows.

Metal concentrations in the surfaced discharge water would be further diluted as it is dispersed with tidal currents. A two-dimensional dispersion model predicts a minimum dilution rate of 10 in 12 hours. Thus, depending on the tide level and flow rate, water discharged at the middle outfall would be diluted a minimum of 65 to 350 times, twelve hours after it was discharged. Comparison of this dilution range to the concentration ratios presented in Table 4-2 indicates only copper would still exceed marine chronic criteria 12 hours after it was discharged.

# 5.3.3 GROUNDWATER

Depending on the tide level and flow rate, the copper concentration at the middle outfall would have to be between 182 and 980 ppb to meet marine chronic criteria 12 hours after the discharge. This estimate assumes an initial copper concentration of 5,557 ppb in the outfall (Table 4-2), a background copper concentration of 0.1 ppb in Puget Sound (PSWQA 1988), and dilution rates of 65 and 350 times. Thus, the copper concentrationat the middle outfall would have to be reduced 5 to 30 times to meet marine chronic criteria 12 hours after the discharge.

Associated with Leaching of Contaminated Fill Materials



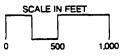
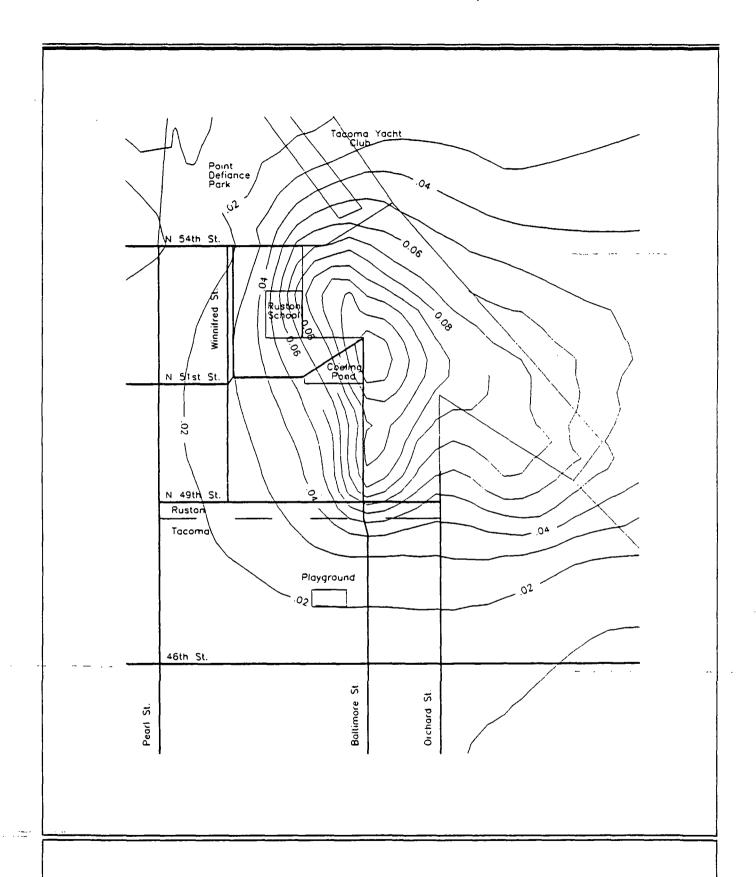




Figure 5-2.
Plant Layout and Source Locations



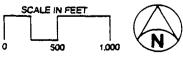
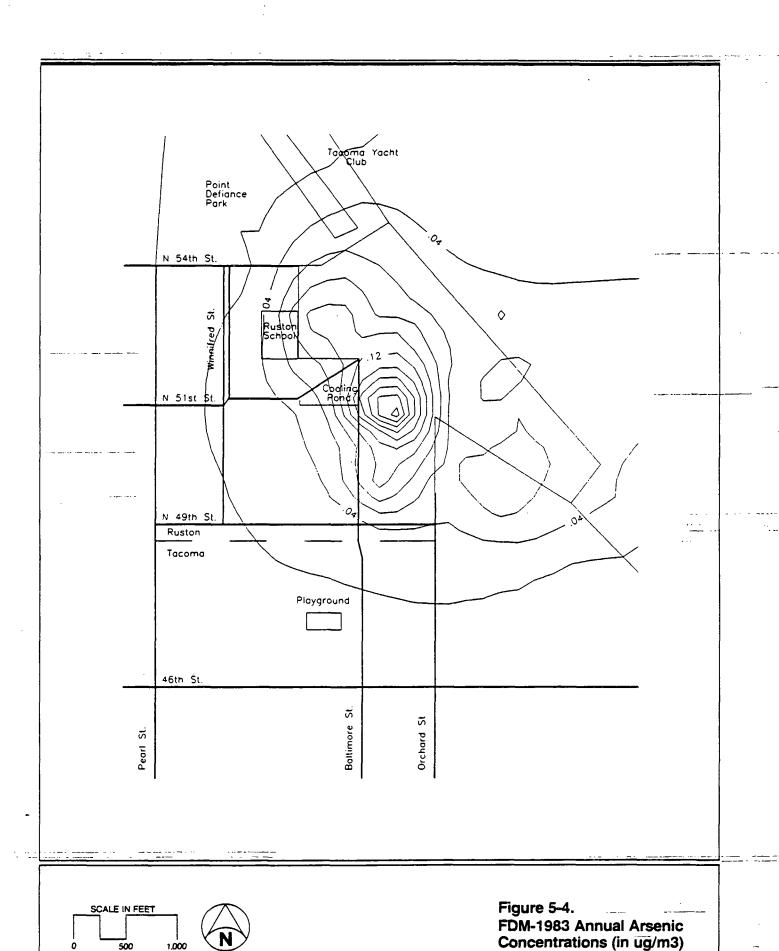


Figure 5-3. ISC-1983 Annual Arsenic Concentrations (in ug/m3)



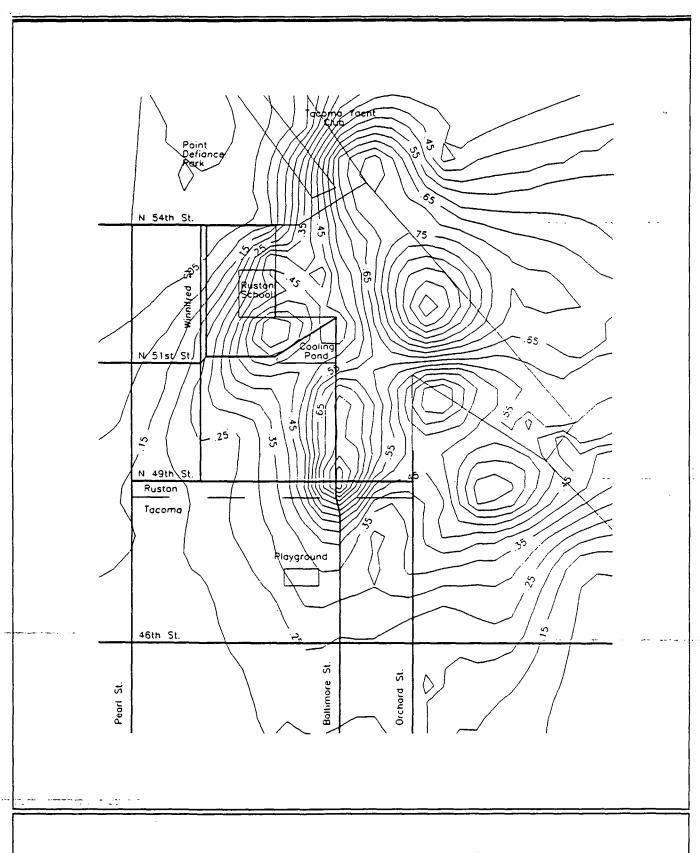
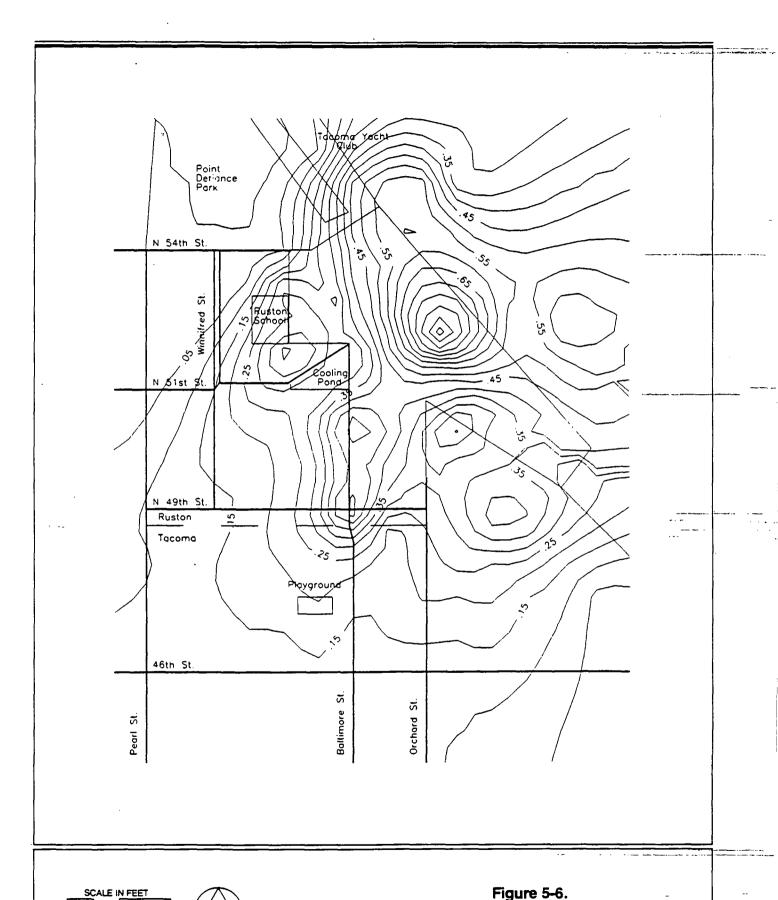






Figure 5-5.
ISC-Max 8 Hour Arsenic
Concentrations (in ug/m3)



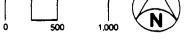
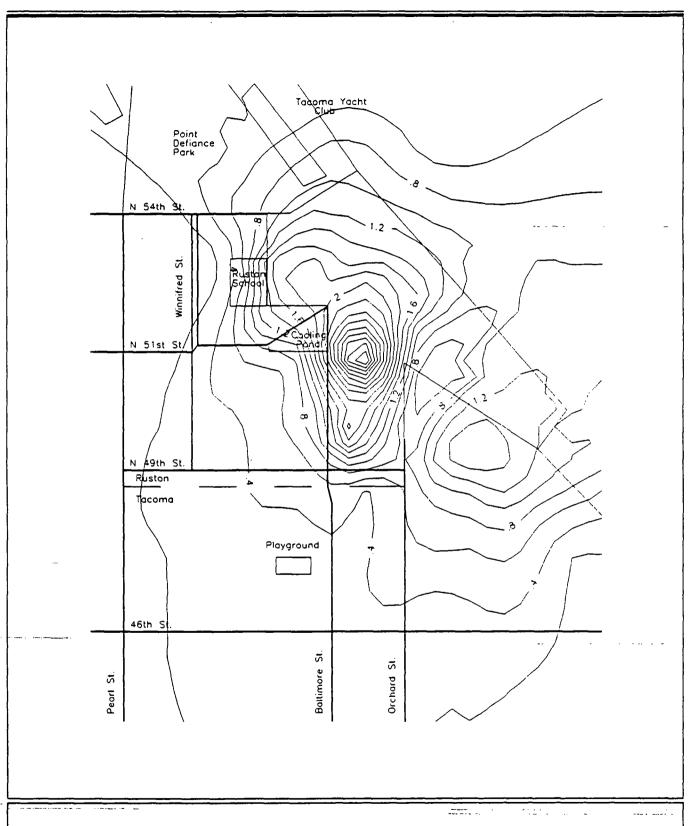
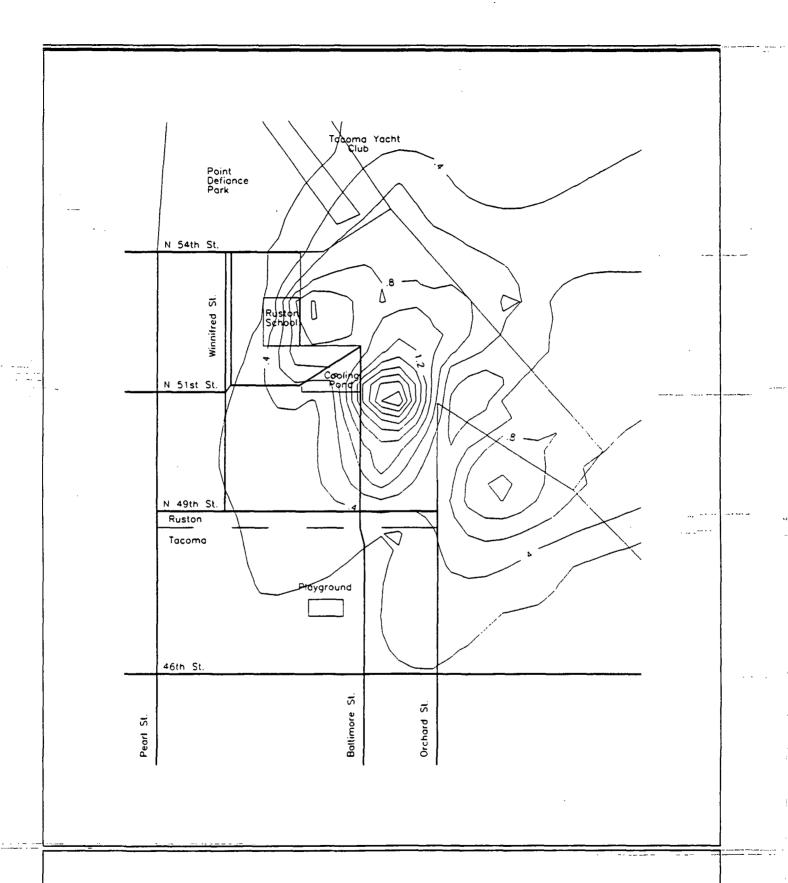


Figure 5-6. ISC-Max 24 Hour Arsenic Concentrations (in ug/m3)







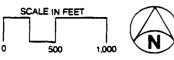
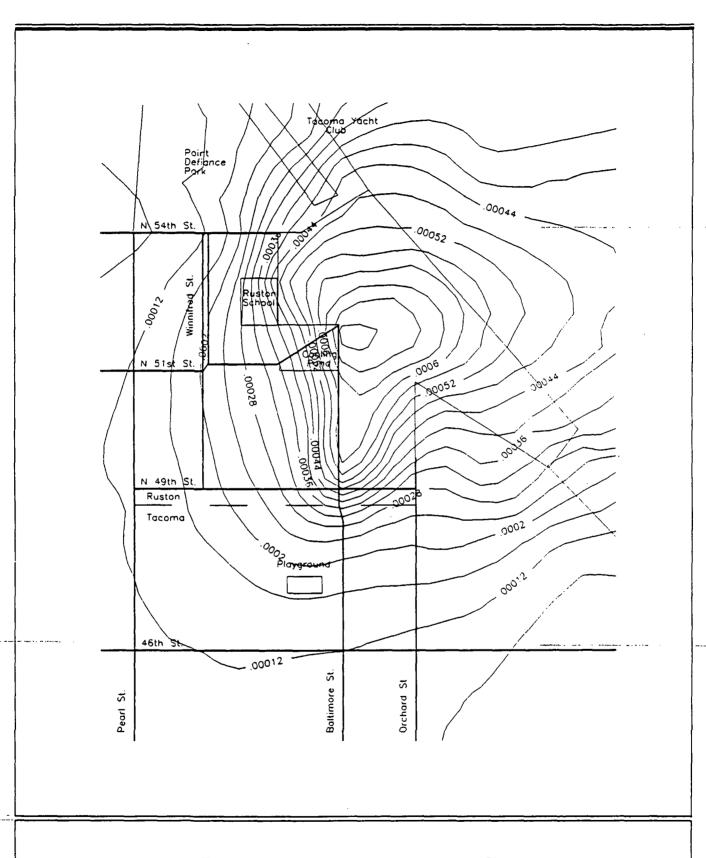


Figure 5-8.
FDM-Max 24 Hour Arsenic Concentrations (in ug/m3)



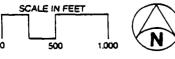
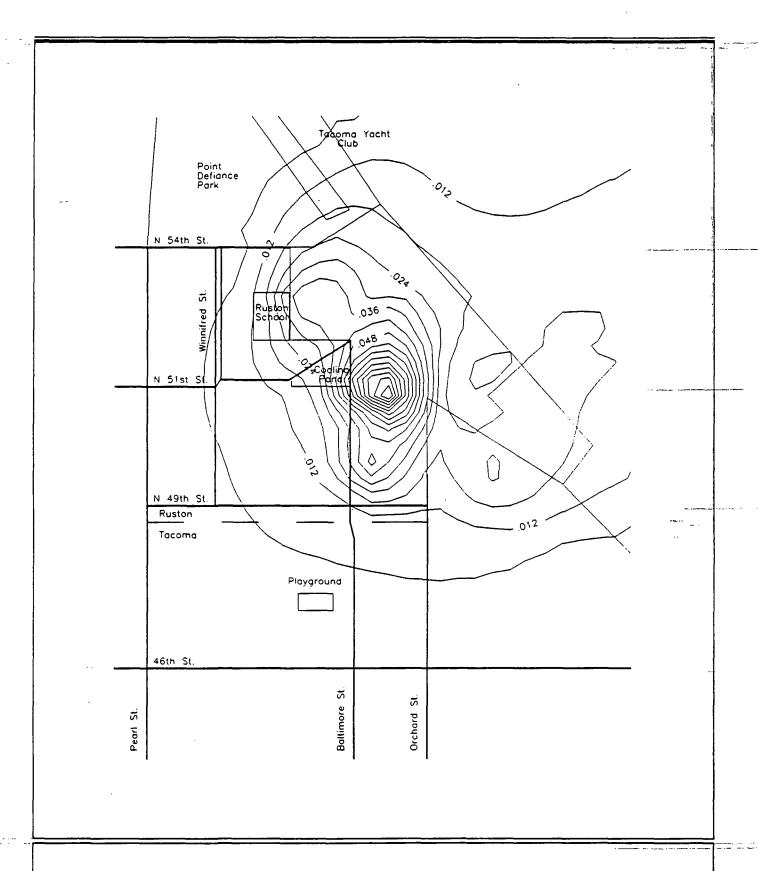


Figure 5-9. ISC-1983 Annual Arsenic Deposition (in grams/m2)



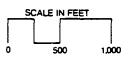
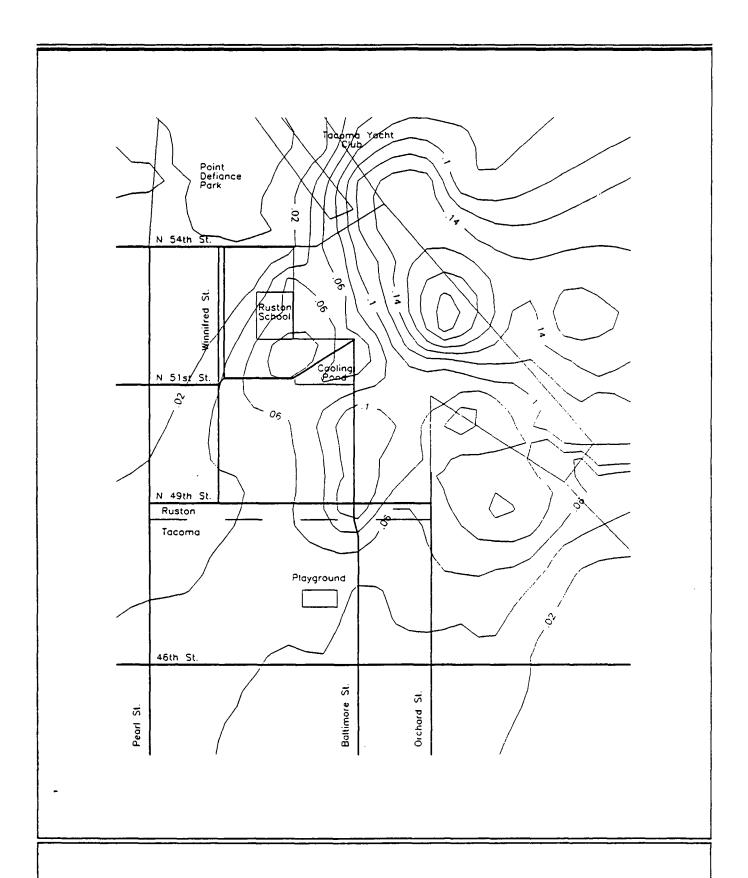




Figure 5-10. FDM-1983 Annual Arsenic Deposition (in ug/m2/sec)



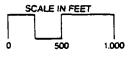
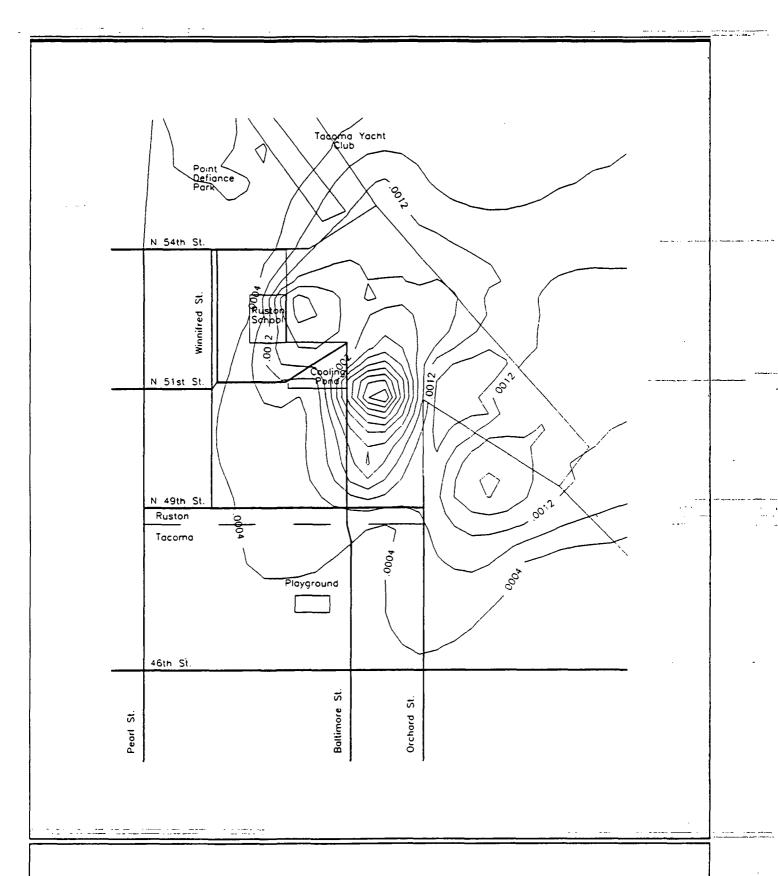




Figure 5-11. ISC-Max 24 Hour Arsenic Deposition (in ug/m3)



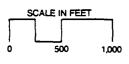




Figure 5-12. FDM-Max 24 Hour Arsenic Deposition (in grams/m2)

#### 6.0 BASELINE RISK ASSESSMENT

### 6.1 BACKGROUND

The Tacoma Plant, owned by ASARCO, Inc., operated as a smelter from 1890 to 1985. The main activities were the smelting of copper and the production of various byproducts including arsenic and liquid sulfur dioxide. The site covers 67 acres bordering Commencement Bay, the Town of Ruston, and sections of urban Tacoma, Washington.

Under the terms of a 1986 consent order, Asarco was required to demolish various facilities associated with copper smelting at the Tacoma Plant, and to conduct a Remedial Investigation and Feasibility Study of the site in agreement with the U.S. Environmental Protection Agency, Region X. In accordance with the consent order, Asarco has completed some site remedial activities such as removal of selected buildings.

As part of the Remedial Investigation, Asarco retained Environmental Toxicology International, Inc. (ETI), to perform a baseline health risk assessment. The baseline risk assessment estimates human health risks associated with lifetime exposure to (1) the chemicals presently in the soil at the site and (2) off-site concentrations of metals in fugitive dust. Three hypothetical exposure scenarios were developed cooperatively by Asarco and EPA to evaluate the risks from residential site use, industrial site use, and off-site residential exposure to fugitive dust. Risks to off-site residents due to the existing levels of metals in soils were calculated in the Ruston/Vashon Island Endangerment Assessment.

This report was prepared for the exclusive use of ASARCO, Inc. and EPA. All work was conducted in accordance with generally accepted state and federal guidelines at the time of our investigation. No other warranties, expressed or implied, are made as to the professional advice provided.

#### 6.2 INDICATOR CHEMICALS

The indicator chemical selection process for this assessment involved a detailed review of the site characterization data, regional background concentrations, soil analytical results, ambient levels in air, chemical toxicity, and chemical environmental fate and transport. Those chemicals that pose the greatest potential health risk at the site were chosen as "indicator chemicals."

Most hazardous substances detected in site soils were metals associated with the smelting and refining operations. The metals selected as indicator chemicals at the site were antimony, arsenic, cadmium, copper, chromium, lead, mercury, and nickel. Organic chemicals of concern at the site were the high-molecular-weight variety of polycyclic aromatic hydrocarbons (HPAHs) and PCBs. These organic chemicals occur in distinct areas of contamination but were not disturbed throughout the site.

Unsubstituted dibenzofuran, unsubstituted dibenzothiophene, and m-nitroaniline were conservatively included as possible chemicals of concern. These chemicals lack the necessary EPA criteria to be quantitatively evaluated by the indicator chemical screen. The available evidence indicated that these chemicals are of minor health concern at the few locations where they were detected on site.

# 6.3 EXPOSURE ASSESSMENT

Three separate scenarios were considered that cover a range of possible exposure conditions for hypothetical populations exposed to the site. These scenarios assumed that current soil conditions remain unchanged (no-action alternative). A residential scenario, which considers lifetime exposure to the site in its current condition by a hypothetical resident living on the site, was used to estimate the worst-case exposure scenario. An industrial scenario considered the potential exposure for workers if the site was developed for heavy or light industry. An off-site residential scenario evaluated exposure to fugitive dust by a population residing near the boundaries of the Asarco property.

The relevant pathways and routes of exposure to indicator chemicals at the site depend on the type of chemical and the population of concern. For on-site residents, the most important pathways were determined to be ingestion of metals and organic chemicals in soil, ingestion of metals in home-grown vegetables, inhalation of metals in dust, and dermal absorption of organic chemicals in soil. Workers were assumed to have the same routes of exposure as residents, except that ingestion of home-grown vegetables was not included as an exposure pathway. For off-site residents, the pathways of concern were inhalation of metals in fugitive dust and ingestion of metals in soil from deposition of dust from the site.

Exposure to surface water in the cooling pond on site appeared to be a less significant exposure pathway than exposure to surface soil. This determination was based on an examination of cooling pond sediment analytical data. Copper may be an exception given the elevated levels of this metal in soil near the pond. A screening evaluation of acute exposure to total metals in storm water runoff yielded no significant exposures, assuming one-time ingestion exposure by children playing in puddles. Exposure to fish in Commencement Bay was studied in the Commencement Bay/Nearshore Tideflats Feasibility Study and thus was not duplicated in this report.

# 6.4 TOXICITY ASSESSMENT

The toxicity assessment section summarizes the toxic effects associated with the calculated doses of the indicator chemicals to which hypothetical on-site and off-site populations are exposed. The EPA criteria used to calculate the quantitative risk estimates from the exposure doses are described. The toxicological properties of many of the indicator chemicals are presented in more detail in Appendix C, including discussion of effects associated with higher concentrations of these chemicals.

Dibenzofuran and m-nitroaniline were evaluated qualitatively in the toxicity assessment because the available data were insufficient to evaluate their associated health risks

quantitatively. The available toxicological information did not indicate that these chemicals would be a major health concern at the low levels that occur on the site. Moreover, neither have been shown to be carcinogenic and thus exclusion of these chemicals from the quantitative risk assessment will not affect the overall carcinogenic risk for the site. Dibenzothiophene lacks sufficient toxicological data to be evaluated. This chemical is structurally similar to dibenzofuran and was detected at lower levels.

# 6.5 RISK CHARACTERIZATION

A range of quantitative risk estimates are given for both carcinogenic and non-carcinogenic effects. Carcinogenic risk is the risk of developing but not necessarily dying of cancer.

Risk estimates for carcinogenic effects due to exposures at the Asarco site were compared to target risk levels set by EPA (10<sup>-4</sup> to 10<sup>-7</sup>). Non-carcinogenic effects were assessed by comparing the dose of each indicator chemical by each route of exposure to the acceptable daily intake for chronic exposure developed by EPA.

The major determinant of carcinogenic risk for the site is arsenic, primarily by ingestion. Risks are highest for the hypothetical residential use scenario (10<sup>-1</sup> to 10<sup>-3</sup>) and about an order of magnitude lower for the industrial use scenario.

Risks associated with HPAHs were 10<sup>-3</sup> to 10<sup>-5</sup> for "worst-case" and "typical" exposure respectively, assuming that all HPAHs are the carcinogenic benzo(a)pyrene. HPAHs were localized to a few areas and were not detected on most of the site.

The risks for the other carcinogenic substances (inhalation of chromium, nickel, and cadmium, and oral and dermal exposure to PCBs) were 10<sup>-5</sup> or lower and within EPA guidelines for allowable exposure.

Risks to off-site residents due to inhalation of carcinogenic metals in fugitive dust were within allowable guidelines. Worst-case risks were 10<sup>-4</sup> at the site boundary and 10<sup>-5</sup> for more realistic exposure at 0.4 km from the site boundary. Arsenic was the primary source of this risk. Based on "worst-case" calculations, deposition of arsenic in fugitive dust is not expected to increase the lifetime risk to off-site residents measurably above current risks calculated for soil ingestion, which have been estimated to be 10<sup>-2</sup> to 10<sup>-3</sup> (Black and Veatch 1988). Despite this relatively high risk (one-in-a-hundred to one-in-a-thousand), epidemiological studies of the surrounding community have not shown statistically significant increases in morbidity or mortality relative to the general population (Black and Veatch 1988). Although epidemiological studies are inherently weak statistically, this discrepancy may also be explained by the tendency for current risk assessment methodology to overestimate cancer risks to most residents near this site and thus to theoretically predict far more cases of cancer in the population than are actually observed. Few individuals would match the worst-case exposure assumptions used such as continuous lifetime residency and high contaminant intake rates.

Major determinants of non-carcinogenic risks are ingestion of lead, and less importantly ingestion of antimony, copper, and cadmium. The latter metals are of concern under "worst-case" exposure conditions but not for more realistic conditions ("typical"). Assuming that children are living at the site with present soil conditions, ingestion of lead in soil is conservatively estimated to result in a dose that is 60 times the "acceptable" dose under "typical" conditions. By comparison, exposure for workers at the site would result in a "worst-case" ingestion dose for lead of five times the acceptable level. "Worst-case" exposure assumes that workers ingest soil during earth-moving activities. Under "typical" exposure conditions, ingestion by workers results in dose estimates below the acceptable level of chronic exposure.

The above-mentioned risk estimates for exposure to lead at the site reflect the conservative assumptions used in this risk assessment. The conservative nature of the lead exposure assumptions used is further indicated by the lack of an increase in blood lead levels in children living near the site due to increased lead levels in soil. Blood lead levels of school children living within a mile of the smelter apparently were not elevated in this area relative to a control population that was not exposed to the smelter (Glass 1984). A conservative approach to risk estimation is justified, however, given the higher lead soil concentrations on site (average = 3,800 ppm) and the growing regulatory concern that adverse effects in children may occur at lower blood lead levels than previously believed to be safe (USEPA 1988b).

Estimated non-carcinogenic risks via inhalation of lead by on-site or off-site populations did not exceed state and federal guidelines and are therefore not expected to cause adverse effects.

#### 6.6 CONCLUSIONS

Residential use of the site would require reduction of primarily arsenic and secondarily lead and HPAHs levels. Risks from all other indicator chemicals are within EPA allowable levels under typical exposure conditions. Industrial use of the site will mainly require reduction of arsenic levels. Worst-case off-site arsenic levels in air are within the 10<sup>-4</sup> to 10<sup>-7</sup> range of target risk levels recommended by the EPA. Worst-case off-site deposition of arsenic in fugitive dust poses a very small increase in soil concentration and risk relative to the existing levels off site.

These conclusions are based on conservative assumptions with regard to acceptable public health exposures as outlined by state and federal guidelines.

### 7.0 SUMMARY AND CONCLUSIONS

This chapter summarizes the significant findings from the remedial investigation, and it briefly discusses how they relate to site cleanup. The actual Determination of Need for Remedial Action and Assessment of Remedial Alternatives are the initial steps of the Feasibility Study phase of the project and are not presented in this document.

# 7.1 AIR QUALITY

Ambient air quality conditions were modeled using wind conditions measured previously at the site, and chemical contaminant concentrations measured in the on-site dust. The modeling efforts were conducted to predict the extent of impacts from air-born dust emissions of material currently remaining on-site.

The results of the air quality efforts indicated the existing impacts of wind-blown arsenic dust are highest on-site, and are not expected to exceed ambient guidelines off-site. The results suggest that off-site cleanup should not occur until the on-site source is controlled. On-site source control will likely be achieved as remedial measures are implemented to clean up surface soil and groundwater.

# 7.2 SURFACE WATER

Surface water sampling indicated a substantial increase in chemical concentrations as surface water passes through the site. The sampling scheme was not intensive enough, however, to identify what portions of the site are responsible for the concentration increases.

The surface water outfalls at the Asarco site discharge to Commencement Bay. The concentrations of metals measured in the surface water during storm events indicates that marine chronic toxicity criteria will be exceeded in the receiving waters, even after initial dilution occurs. Cleanup of the surface water will be necessary to eliminate impacts to the marine receiving waters. The level of clean up will be based on the amount of dilution that occurs in the receiving waters. Outfall dilution modeling further indicates that existing surface water metal concentrations will have to be reduced 5 to 30 times (depending on tidal conditions) for the discharge to meet marine chronic criteria. That means surface water chemical concentrations will have to be decreased through control measures aimed directly at surface water clean up (i.e., clean out of surface water collection and outfall pipes) and indirectly through measures to clean up surface soils.

The RI also indicated that the south outfall is not structurally intact. Flow volume measurements made along the conduit leading to the south outfall indicate flow decreases in areas where it normally should increase if the conduit is structurally sound. Surface water apparently leaks out of broken pipes into the surrounding groundwater. Remedial activities addressing surface water cleanup also need to address the integrity of this existing system and correct any problems associated with it.

#### 7.3 SUBSURFACE SOILS

Three different types of analysis were conducted on the subsurface soil samples: total, EPTox, and column fill/slag leaching tests. The total and EPTox results for metals analysis were highly variable spatially. This spatial variability was both horizontal and vertical. In general, the slag fill had the highest total metal concentrations while the granular fill had the highest EPTox values.

The fill/slag leaching laboratory tests that were performed indicated the granular fill material leached significantly higher concentrations of metals than the slag fill. The most leachable material, of those areas tested, is present in the area where the arsenic kitchens were located on the site.

The results of the metals analysis, for the three types of tests performed, indicates that cleanup of the granular fill material will be the most productive source control measure for removing leachable materials that are sources of groundwater contamination. The location of granular fill material is generally identifiable through the boring logs from the geology and groundwater investigations.

Organic compounds were also present in subsurface soils in select areas of the site. Dimethylaniline (DMA) was present in soils at sites B-17 and B-36. Its presence at one of the sites (B-36) is explained by plant processes that occurred in that vicinity. The presence of DMA at the other site (B-17) is not so easily explained, but may be due to surface water collection and treatment activities that took place near B-17.

Other organic compounds detected in some of the samples were petroleum byproducts. These compounds were detected in the northeastern portion of the plant. GC-FID fingerprints of the petroleum indicate it is a weathered, fairly heavy fuel oil that has limited mobility.

#### 7.4 GROUNDWATER

Metals were present in most groundwater samples collected throughout the site. Over 90 percent of the samples analyzed for total metals had detectable levels of arsenic, copper, and zinc. The spatial distribution of metals indicated the plant area had the highest concentrations with average arsenic, copper, and zinc levels about one to two orders of magnitude higher than the stack and parking lot areas. The stack and parking lot areas had similar concentrations of most metals except arsenic. Average arsenic concentrations in the stack area were about ten times higher than the parking lot area.

Of the organic compounds analyzed, only DMA appeared in concentrations indicating that it could be migrating to the Bay. This is based on the discovery of DMA in relatively high concentrations in B-37, and in lower concentrations down-gradient from there in MW-1A.

Although petroleum products were detected in the subsurface soil in the northeastern portion of the plant, no petroleum products were measured in monitoring wells that would indicate it is migrating towards the Bay. Free floating petroleum was not detected in any of the wells, and only well B-36 had any petroleum hydrocarbons detected in the groundwater.

Several mechanisms are believed to be the cause of groundwater contamination at the Asarco site:

- groundwater contact with leachable fill materials
- infiltration of surface water and precipitation through leachable fill materials
- leakage of contaminated wastewaters and subsequent migration into groundwater
- · spills or leaks of dimethylaniline.

Based on the slag/fill leaching studies, the primary source of groundwater contamination is the leaching of contaminated fill materials.

The primary receptor of groundwater contamination at the site is Commencement Bay. The rate of discharge of groundwater into the Bay varies depending on tidal conditions. During high tide, the groundwater gradient reverses, and there is no discharge to Commencement Bay. During low and intermediate tides, discharge to Commencement Bay occurs.

Based on flow and time weighted averages, the estimated average concentration of arsenic in the groundwater discharged to Commencement Bay was 7,300 ppb. Arsenic had the highest concentration of metals analyzed from groundwater.

# 7.5 MARINE ENVIRONMENT

Sampling in the marine environment included chemistry, benthos, and bioassay tests. The results of this monitoring indicate that a number of factors are responsible for the type of organisms in the marine environment offshore from Asarco. These factors include sediment particle size distribution, depth, topographical relief, water current velocity, sediment composition, chemical concentrations within the sediment, and bioavailability of the chemicals. The data from the three types of sampling indicate contradictory results. Some stations have high chemistry levels and poor bioassay survival, but have extremely rich and diverse benthic communities. Other stations have low chemistry levels, but marginally diverse and abundant benthic communities. Still other stations fall somewhere in between this spectrum.

Sorting out differences among chemical effects, physical effects, and bioassay protocol applicability is often impossible. Examples of some of the contradictions that occur are stations with:

- high surficial chemistry values and abundant and diverse benthic communities
- poor survival and abnormal larvae development in bioassay tests and healthy larvae recruitment in the benthic community
- poor amphipod survival in ten-day bioassay tests and amphipod abundance (different species) in the benthic community
- low surficial chemistry values and low diversity and abundance in the benthic community

Although it is difficult to explain the results observed due to such contradictions, two conclusions are possible:

- The use of AET values based on bulk chemistry values is not appropriate for the sediment characteristics offshore from the Asarco site. Slag does not appear to leach the contaminants based on the EPTox data, and organisms appear to take advantage of the unique physical qualities associated with the slag particles. There are too many instances where the bulk chemistry value suggests an apparent effect should occur, yet the benthic or bioassay data do not support the conclusion.
- There is a nearshore station (T12-1) where toxic effects are occurring. This is based on consistent results between sediment chemistry, bioassay tests, and benthic samples. Toxic effects are also likely at Station T6-1 where sediment chemistry and bioassay tests agree. Benthic analysis was not done at this station.
- There may be toxic effects occurring at Station T10-1. This station has high sediment hydrocarbon levels and appropriate bioassay effects, with some reduction in the number of taxa found and the station biomass.

The marine sediment core data indicate that high surficial chemistry values decrease markedly at about .3 to .4 m in the sediment core. These results are consistent with the Commencement Bay Nearshore Feasibility Study (Tetra Tech 1989).

# 7.6 SUMMARY

The results of the Remedial Investigation provide a definition and boundary to the type and extent of contamination occurring at the Asarco Tacoma Smelter site. Through the use of carefully selected source control clean-up measures, remediation of site contamination should be feasible and not adversely impact the primary receptor, Commencement Bay. None of the data collected during the RI portion of this RI/FS suggest there is a catastrophic contamination affecting the environment at the Asarco site. The data also suggest that the remediation will likely be technically and practically achievable, yet still be effective in protecting Commencement Bay.

# Chain of Custody

A chain-of-custody was completed for every soil or water sample collected in this study. Chain of custody forms were filled out, signed and countersigned for transfers of samples from the possession of the field geologist to that of the Hart Crowser chemist. Receipt of sample shipments from Hart Crowser to the Asarco Salt Lake City and Lancaster laboratories were acknowledged by signature on the chain-of-custody document. Original chain-of-custody documents and copies are maintained in the Quality Control and Quality Assurance records of Hart Crowser.

Chain-of-custody seals were used routinely to assure the security of the sampling and shipment process. Seals were placed over the interfaces of shipping coolers and their lids, and over capped well casings temporarily left unprotected by locked well monuments during the course of drilling.

# Health and Safety

The health and safety program for field operations addressed a range of potential hazards at the Asarco site. This program included the on-site maintenance of protective equipment, routine monitoring decontamination procedures, and documentation.

Protective equipment used in field operations included fit tested full-face respirators for all personnel. These were fitted with GMC-H cartridges. Respirators were used during all ODEX drilling operations to prevent inhalation of slag dust. Respirators were also used on other occasions whenever dust was detectable from any source on-site.

Tyvek coveralls, goggles, rubber gloves, and rubber boots were typically worn at all times during drilling, sampling, and well development operations to prevent contamination of clothing and skin by potentially hazardous materials. Tyvek coveralls were changed at least once per day and boots, goggles, and gloves washed frequently.

Every boring operation was delineated into an exclusion zone by the use of hazard type. A decontamination line comprised of a sequence of large tubs containing detergent water, rinse water, and tap water was set up for washing boots and gloves of workers leaving the exclusion zone. All equipment and clothing, including Tyvek coveralls used inside the exclusion zone, were left inside the hot line.

Monitoring was performed on a frequent, regular basis during drilling. On an hourly basis an MSA 361 meter was used to detect levels of  $H_2S$ , oxygen, and flammable gases; an H-Nu PI-101 photoionization meter was used to monitor levels of organic vapors; and a Victoreen 450 radiation meter was used to detect ionizing radiation. Dust samples were taken on a daily basis by the use of an MSA Flow Lite pump drawing 120 liters of air through a dust filter. These filters were analyzed for heavy metal content.

A daily record was kept of protective equipment used, delineation layouts, and monitoring equipment readings.

Deionized water and tap water were simply poured into sample jars. Samples collected for dissolved metal analysis were filtered through a 0.45  $\mu$  Sample Pro disposable filter.

After collection, sample handling procedures were identical for all samples. Sample jar kits were assigned to each sample. Each jar was labeled according to its category of chemical analysis. Preservative solutions were measured and added to samples as required by the schedule below (Table B-6).

Table B-6. Preservative solution sample schedule.

Quantity Kit	Container	Analyses	Preservative Added/Container
2	500 ml plastic (or 1 1000ml) jar(s)	metals	2.0 ml HNO <sub>3</sub> (conc.) 0.45 micron filtered
1	1,000 ml plastic jar	metals	none
4	1,000 ml amber glass jars	extractable organics	none
1	250 ml amber glass jar	sulfides	0.2 ml ZnOAc and 0.5 g.NaOH
1	125 ml amber glass jar	total organic carbon	$0.5 \text{ ml H}_2SO_4 \text{ (conc.)}$
2	40 ml amber glass jars	volatile organics	
1	1,000 ml polypropylene jar	gross alpha	none

All sample jars were multiple wrapped with bubble packing material, then placed in styrofoam-lined boxes with the completed chain-of-custody forms for shipment. Each box received several bags of frozen Blue Ice to keep samples cool. Chain-of-custody seals were applied to the styrofoam liner lid and sides. Styrofoam shipping "peanuts" were added to completely fill all remaining space within boxes. Finally, all boxes were labeled and addressed for shipment to laboratory for chemical analysis. Samples were generally shipped to Asarco Salt Lake City and Lancaster laboratories within one day of collection by DHL Courier.

B-23 B-28, B-29, B-30 and B-32, using falling and rising head methods. They were conducted between December 17 to 23, 1987. Wells MW-3B and MW-11 were dry at the time of testing.

Falling head test was performed by instantaneously lowering a 1-inch-diameter, 5-ft-long solid PVC rod (slug rod) into the well and continuously monitoring the falling in water level in the well bore using the Hart Crowser field data acquisition units. After the well water level returned to static condition, a rising head test was performed by instantaneously removing the slug rod from the well and continuously monitoring the rise in water level in the well bore. All wells reached static conditions within 25 minutes from the beginning of a test. The Hart Crowser field data acquisition unit consisted of a pressure transducer, TERRA 8D field data logging unit, and a IBM lap-top computer assembly. Data for each test were stored in 3-1/2-inch diskettes.

The pressure transducer and slug rod was washed with deionized water between wells and a dedicated piece of new rope was used to lower the slug rod at each well to prevent cross contamination between the wells.

The data were analyzed using Bouwer's (1978) or Hvorslev's (1956) methods. The data logging and transfer from the TERRA 80 system were done as outlined in Terra operating manual.

A summary of estimated hydraulic conductivity values are given in Tables 3-1 and 3-2.

# Water Sampling

Water samples were taken for chemical analysis from all water bearing wells (MW-11, B-20, B-23, B-23R, B-28, B-29, and B-30 were dry at the time of sampling), two springs, cooling pond, drill rig tanks, steam clean spray, steam cleaning rinseate, tap water used to fill drill rig tanks and deionized water used for rinsing samples and well probes. In conjunction with sampling, other water measurements were taken including temperature, pH, conductivity, dissolved oxygen, salinity, and water levels in wells. These data are presented in Tables B-1 and B-2.

Water samples were also collected in well nests at the MW-1, MW-2, and MW-3 locations during highest high intermediate and lowest low on October 19, 1988. Field data collected during this sampling event are presented in Table B-3.

Sample collection procedure varied by source. Spring water was dipped from the surface of a small pool into the sample jar over the spring. The cooling pond water was sampled by dipping a stainless steel bowl from the platform on the northern edge of the cooling pond. Sea water was collected from the tidal gaging station using a peristaltic pump. The wells were sampled either by bailing or by using a single or double head perastaltic pump described in the Well Development section. Steam cleaning water was collected from the steam cleaner spray nozzle at full pressure and steam cleaning rinsate was collected from water sprayed through a joint of HSA pipe.

#### Decontamination Procedures

Drilling, sampling, and testing equipment were routinely decontaminated in the field. Routine decontamination of drilling and soil sampling (including backhoe for test pits) equipment between explorations consisted of steam cleaning in a detergent solution (ALCONOX) followed by a tap water rinse. PVC components (screen, riser, end caps) used in well construction were also steam cleaned and rinsed in tap water prior to installation. Components were temporarily stored in plastic protective wrap for transportation prior to final assembly at installation.

Other testing equipment was routinely decontaminated included the pH and specific conductance meters, water level probes. Decontamination after each use consisted of rinsing of equipment probes in deionized water.

# Water Level Measurements

Water level measurements were made for each boring at the time water was first observed during drilling. Subsequently sets of water level measurements were made of all wells installed during the drilling program. These were made before and after well sampling and well development, and intermittently to weekly thereafter. Water level monitoring data is shown in Tables B-1 through B-5.

Continuous monitoring of water levels was conducted during Phase I and Phase II, using the Hart Crowser automatic data acquisition system (see K-testing). During Phase I wells MW-2A, MW-2B, MW-6, and MW-8 were monitored during the period 17 to 23 December 1987. During Phase II wells B-34, B-35, B-14, MW-6 and the tidal gage were monitored during the period of November 14 to 17, 1988. These data are graphically presented on Figure 3-25.

A series of three sets of water level measurements were made during a single tidal cycle occurring on January 19 and 20, and November 10 and 11, 1988. These measurements were made at highest high, intermediate, and lowest low tides in order to identify tidal effects on the groundwater table as established by water levels in the wells. A surface water gaging station was also installed during Phase I on the north dock (Figure 3-10) to allow measurements of sea water levels during monitoring. The monitoring data for Phase I and II are presented in Tables B-4 and B-5.

Water level measurements were made to a measured accuracy of 0.01 ft with an Olympic Model 150 Electric Well Probe and a decimally graduated tape measure. The tip of the well probe was routinely rinsed with deionized water between wells in order to prevent chemical cross-contamination.

### Hydraulic Conductivity (K) Testing

In situ hydraulic conductivity tests (slug test) were performed at all Phase I and Phase II monitoring wells where sufficient water existed in the well. Both falling and rising head tests were conducted. Wells not tested included MW-3B, MW-11, B-20, B-21, B-22,

monument. Well construction information and field test results are presented on Figures B-2 through B-42 and in Tables B-1 and B-2.

Monitoring wells were installed in each of the Phase II borings except B-15, B-23, B-24, and B-25.

# Well Development

All wells completed in the course of this study were developed (with the exception of MW-11, B-24, B-28, B-29, B-30, B-20, B-22, and B-23R, which contained no water). Phase I wells were developed by the use of a Cole Parmer Model 7019 high capacity dual head peristaltic pump with the exception of wells MW-8, MW-12, and MW-13 which were developed by hand bailing. Phase II wells were developed using an Instrument Northwest pneumatic actuated well development pump, except wells B-17, B-21, B-26, B-27, B-31, B-33, B-34, B-36, and B-37, which were developed by hand bailing.

After installation, fine-grained sediment in the well was removed by purging water from the wells. This purging process, which is referred to as "well development," consists of pumping a water volume of at least 3 to 5 times times the volume of the well casing. In a few cases a much larger volume was required. Several wells, however, remained turbid after two development sequences. Well development data are presented in Tables 1 and 2.

#### Test Pits

A total of seven test pits, designated TP-1, TP-2, TP-3, TP-5, TP-6, TP-7, and TP-8 were completed on 10/4/88 and 10/5/88. The test pits were excavated to a depth ranging from 2 to 6 ft. These depths were determined by the Hart Crowser field representative during the excavation.

The test pits were excavated using a backhoe under subcontract to Hart Crowser.

The samples were collected by excavating a test pit to determine the layer of potential contamination and then a second adjacent hole was excavated for sampling. A stainless steel spoon was used to remove the sample material from the backhoe bucket and fill a clear plastic bucket which was then covered with a plastic lid and taped closed. The sample was then returned to the Hart Crowser lab for leachate testing.

The sampling equipment and backhoe were cleaned before and after each test pit excavation. The backhoe bucket and a portion of the connection boom were thoroughly cleaned using a hot water pressure washer with a detergent first stage and a secondary rinse. The sampling equipment was hand washed using detergent and water, then rinsed with deionized water. Generally, the test pits were backfilled with the excavated soil using the backhoe, tamping the soil during replacement to reduce later settlement.

In Phase II, eight borings were advanced through the massive slag layers in the slag fill area using the ODEX system. These include boring B-15 and monitoring well B-14, B-16, B-33, B-34, B-35, B-36, and B-37. After the massive slag was penetrated, the HSA system was used to obtain the final depth.

The ODEX drilling equipment employed for this investigation was a truck-mounted rig which uses air pressure to advance an expandable carbide-tipped bit followed by a 5-inch ID casing. Sampling was done at variable intervals using a large, 3-inch split-spoon sampler driven with a 300-lb hammer dropped 30-inches. This larger hammer and sampler generate blow counts which are comparable to the standard 2-inch sampler and 140-lb hammer.

# Soil Sampling

Most soil samples were collected by the SPT "split-spoon" method described above. This yields a disturbed sample of soil. At times, however, it was possible to obtain relatively undisturbed soil samples by pushing a thin-walled tube sampler (Shelby Tube). The Shelby tube sampler is a 3-inch ID thin-walled steel tube hydraulically forced into fine-grained sediments.

Shelby tubes were wiped clean, labeled, and the ends sealed tightly with vinyl end caps. These were transported and stored in a vertical position to maintain integrity of the sample inside. Subsequently these samples were extruded in the Hart Crowser laboratory for visual description, grain-size distribution and permeability testing (Appendix E).

Split-spoon soil samples were placed in clean glass jars with TEFLON-lined lids. Each sample jar and lid was labeled with the date and time of sample collection, borehole number, sample number, and footage interval below ground surface. Jars were placed in a cooler supplied with sealed ice packs. This cooler was kept inside the field representitive's vehicle at all times until delivery to the Hart Crowser laboratories.

Samples were delivered to the Hart Crowser laboratories each afternoon. Selected samples were bubble wrapped, placed in styrofoam lined cooler boxes with ice packs, and completed with chain-of-custody forms. These boxes had chain-of-custody seals across the joint of the cooler and the cooler lid. Samples were shipped by DHL Courier with completed chain-of-custody forms for overnight delivery to the Asarco Salt Lake City and Lancaster Laboratories Inc. laboratories for chemical analyses.

#### Well Installation

All wells are of 2-inch-diameter Schedule 40 PVC single well construction and have either 5- or 10-ft screened sections (0.02-inch slot size). Wells were installed at selected depths by lowering the casing to the desired depth. Colorado 10/20 sand was used to backfill the space around the screen to a level 1 to 2 ft above the top of the well screen. One and one-half to 2-ft of fine sand was placed above the filter material. Volclay grout was placed above the screened sections to within approximately 2-ft of the ground surface. All wells have a concrete surface seal and are protected by a 6-inch steel

considered accurate to within 0.01 ft. All elevations were measured using the City of Tacoma datum.

Summaries of well completion, groundwater sampling, water level data and hydraulic conductivity data are shown in Tables 1 through 5.

# Hollow-Stem Auger (HSA) Borings

Phase I HSA auger borings included B-2C, B-2C2, MW-4, MW-5, MW-6, B-7, MW-8, MW-9, B-10, MW-11, MW-12, and MW-13. These were drilled from 9/21/87 to 10/16/87 and were completed within a wide range of depths, from 76 ft (MW-13) to 28 ft (B-2C) below ground surface.

Phase II HSA borings included B-15, B-17, B-18, B-19, B-20, B-21, B-22, B-23, B-23R, B-24, B-25, B-25R, B-26, B-27, B-28, B-29, B-30, B-31, B-32, B-33, B-34, B-35, B-36, and B-37. These were drilled from 8/18/88 to 9/16/88 and were completed within a range of depths from 10.5 ft (B-21 and B-22) to 92 ft (B-15) below ground surface. Boring B-23R and B-25R were installed subsequent to reevaluation of the data obtained while drilling B-23 and B-25.

Borings were advanced with a truck-mounted drill rig using a 4-inch inside diameter hollow-stem auger. The drilling was accomplished under the continuous observation of the Hart Crowser field representative (Neil B. Shaw). Detailed field logs were prepared of each boring. Samples were obtained at 2.5- to 10-ft intervals using the Standard Penetration Test (SPT) procedure and thin-walled Shelby Tubes.

\$ :

In most cases the Standard Penetration Test procedure as described in ASTM 1587 was used to obtain disturbed samples; however, other sampling procedures were used and are noted on the drill logs. While performing a Standard Penetration Test, a standard 2-inch outside diameter, split-spoon sampler is driven into the soil a distance of 18-inches using a 140-lb hammer, free-falling 30 inches. The number of blows required to drive the sampler the last 12 inches is the Standard Penetration Resistance. This resistance or blow count provides a measure of the relative density of the granular soils and the consistency of the cohesive soils. The blow counts are noted on the field boring logs at the respective sample depths. Samples were recovered from the split-spoon sampler, field classified, and tested for pH.

# ODEX Borings

In Phase I, eight borings were advanced using the ODEX system in the slag fill area including borings B-1A and B-3A and monitoring wells MW-1A2, MW-1B, MW-2A, MW-2B, MW3A2, and MW-3B. All ODEX borings were completed from 10/7/87 to 10/16/87. Borings ranged from 13 ft (MW-3B) to 33 ft (B-3A).

#### APPENDIX B

# FIELD METHODS FOR THE GEOLOGY AND GROUNDWATER INVESTIGATIONS

The field work for this project was conducted in two phases. Phase I of this project was completed between September 21, 1987 and January 20, 1987 by Hart Crowser, Inc., and its subconsultants. Hart Crowser's field representative for the project was Niel B. Shaw, and field manager was Steve R. Fuller.

The field work for Phase II of this project was completed between August 29, 1988 and September 15, 1988 by Hart Crowser, and its subconsultants. Hart Crowser's field representatives for the project were David K. Babcock, Mike W. Ehlebracht, Paul C. Frankel, and Neil B Shaw. The field manager was Scott E. Wright.

Hydrogeological and geochemical direction were provided by Dharme Rathnayake, Paul Frankel, Philip Spadaro, and Mike Ehlebracht at Hart Crowser. Project representative for Asarco was Curtis E. Dungey, Project Coordinator, for the Tacoma Facility.

Soil Sampling, Inc., of Puyallup, Washington, under subcontract to Hart Crowser completed the drilling, soil sampling, and well installation activities. Parametrix Inc. of Bremerton completed the surveying activities. Soil and groundwater samples collected for chemical analysis were shipped to Asarco Salt Lake City Laboratories and Lancaster Laboratories in Lancaster Pennsylvania by DHL courier.

# Introduction

Phase I and Phase II of the subsurface exploration included the completion of 46 borings:

Thirty were by hollow-stem auger (HSA), 8 were by ODEX, and 8 by using a combination of hollow-stem auger and ODEX equipment. The ODEX was used to penetrate the highly resistant slag. Standard hollow-stem auger equipment was used after the slag had been penetrated or where there was no slag fill.

The exploration logs and groundwater monitoring well construction details are presented on the exploration logs within this Appendix (Figures B-2 to B-42). Exploration logs are a representation of our interpretation of the drilling and sampling, and field testing information. The depth where the soil or characteristics of the soil changed is shown in these figures; however, the actual changes may be gradual. Soil samples recovered in the explorations were visually classified in the field in general accordance with the method presented on Figure B-1.

The exploration locations were located in the field by hand taping or pacing from existing physical features. The ground surface and top of well casing elevations as presented on the boring logs were provided by Parametrix Inc. Locations and elevations of wells are

# APPENDIX B

FIELD METHODS FOR THE GEOLOGY AND GROUNDWATER INVESTIGATIONS

- 4. Mount the adaptor dome, centering it over the filter frame with alignment bolts. Flip up the wing nuts and moderately tighten the assembly together.
- 5. Attach the flexible hose to the top of the adapter dome with the twist-lock connector. Assemble the wand and brush.
- 6. Operate the sampler with the support strap slung over one shoulder, keeping the filter horizontal during sampling. Maintain this orientation until the filter and sample dust are unloaded.
- 7. Start the sampler and vacuum the road surface from the centerline to the edge of normal traffic flow. Avoid collecting too much material from the curb area where there is a high concentration of debris. Vacuum a large enough section of the road to collect a layer of material about 1/8 to 1/2 inch thick. If not sampling a paved road, vacuum a representative portion of the source area.
  - CAUTION: When road dust sampling, always be on the lookout for oncoming traffic. Select the sampling period for times when traffic volume is low and wear reflective orange vests.
- 8. Shut the sampler off when the volume of air passing through the outlet hole has dropped significantly. This indicates that the filter is nearly loaded with dust. Disconnect the flexible hose and place the sampler on a level surface to unload the sample dust. If the wind is blowing, it is advisable to find a more protected area, such as inside a vehicle.
- 9. Loosen the wing nuts and remove the adapter dome from the filter frame. Carefully lift the corners of the filter while shifting the sample material to the center of the filter. Transfer the sample into a Ziploc bag and place the folded filter in the Ziploc bag along with the sample.
- 10. Record the project, date, sample ID number, initials, sampling location, and other comments on the data sheet. Record project, date, sample ID number, and initials on the Manila envelope. Place bagged sample and data sheet into the envelope and seal.
- 11. Hand carry the samples back to the laboratory; log them in and place in the sample storage cabinet.

#### APPENDIX A

# ROAD DUST SAMPLING STANDARD OPERATING PROCEDURE

#### GENERAL DISCUSSION

The objective of the road dust sampling was to obtain representative samples of the road dust likely to be entrained in the ambient aerosol. This procedure also included unpaved sources that have a minimum dust layer.

Criteria for sample location selection included proximity to ambient sampling sites, accessibility, potential contribution to the ambient aerosol, past studies, and a desire to obtain a representation of a variety of road dust types.

# MATERIALS AND EQUIPMENT

Road Dust Sampler - consisting of an enclosed hi-vol motor and filter holder fitted with an adapter cone, hose, brush, and shoulder strap

- Glass fiber filters, 8 x 10 inches
- Portable generator or other 115 VAC, 8A, 50/60 hz power source
- Extension cord, 25 feet
- Ziploc bags
- Manila envelopes, about 7 x 10 inches

# SAMPLE COLLECTION

- 1. Clean the hose, brush, adapter dome, and filter frame with a stream of exhaust air from the hi-vol motor unit. Disassemble the hose sections and shake the flexible portion of the hose to help dislodge any dust in the system.
  - \*Note: A more thorough cleaning may be done between sampling sites by wiping the inside of the adapter dome with a Kim-wipe towel dampened with ethanol.
- 2. If the filter cartridge holder is not already attached to the hi-vol motor unit, make this connection and hand tighten the screw top lid. There is no need for disassembly of these parts until the project is completed.
- 3. Place the wire screen filter frame on top of the filter cartridge holder. Place a clean filter on the screen, being careful to center the filter on the frame.

# APPENDIX A

# ROAD DUST SAMPLING STANDARD OPERATING PROCEDURE

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ASARCO - Remedial Investigation Table 8-1 Well and Hydrologic Data

Table 8-1 Well and Hydrologic	Data																
PHASE I WELLS		1	•••••••		••••••				PHASE I	· · · · · · · · · · · · · · · · · · ·	• • • • • • •	•	· · · ·	•••••			
		·	•••••											• • • • • •			
Well & Boring Data \ Name	(units)	MW-1A	MW-18	MV-2A	MW-2B	MW-3A	MW-38	MU-4	MU-5	MM-6	8-7	MV-8	MU-9	B-10	MV-11	MJ-12	HV-13
Date Installed	••	150ct87	150ct87	90ct87	120ct87	130ct87	140ct87	7 10ct87	7 305ep87	50ct87	None	20ct8	7 28\$ep87	None	215ep87	24Sep87	23Sep87
Total Boring Depth	feet	25.0	15.0	31.5	20.0	21.0	13.0	34.0	69.5	42.5	35.0	35.0	36.5	53.0	36.5	45.0	76.0
Top of Screen - BGS	feet	14.5	9.5	20.0	9.0	15.0	7.0	15.0	25.0	27.0	•-	15.0	10.0	••	11.0	30.0	49.D
Bottom of Screen - BGS	feet	24.5	14.5	30.0	19.0	20.0	12.0	25.0	35.0	32.0	••	25.0	20.0		16.0	40.0	59.0
Top of Screen Elevation	feet	8.2	13.1	4.9	16.0	11.4	19.5	21.9	23.7	-1.0	••	10.0	15.5		139.2	21.0	48.4
Bottom of Screen Elevation	feet	1 2.00	8.1	-5.1	6.0	6.4	14.5	11,9 2.00	13.6	-6.0	••	0.0 2.00	5.5	••	134.2	11.0	38.4
Casing Size Casing Material	inches type	! PVC	2.00 PVC	2.00 PVC	2.00 PVC	2.00 PVC	2.00 PVC	PVC	2.00 PVC	2.00 PVC	••	PVC	2.00 PVC		2.00 PVC	2.00 PVC	2.00 PVC
,	· ypc		shed 40						shed 40		••	shed 40	_	••	shed 40		shed 40
Screen Stot Size	inches	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020		0.020	0.020		0.020	0.020	0.020
GS Elevation	feet	22.71	22.61	24.86	24.98	26.40	26.48	36.93	48.65	26.03		25.02	25.54	9.87	150.22	51.02	97.41
TOC Elevation	feet	24.31	24.30	27.15	26.15	28.99	29.10	38.69	51.00	28.19		26.40	27.06	•••	152.07	52.67	98.48
Well Development Data	(units)	MV-1A	MV-18	MV-ZA	MV-28	MV-3A	MW-38	MU-4	HW-5	MW-6	B-7	MV-8	MU-9	B-10	M¥-11	MV-12	<b>13</b>
••••••							•••••			•	•••••	·	•••••		••••		
Date Development Completed	••	•		210ct87							• •		220ct87	••			230ct87
- Water-Level BGS	feet	7.20	7.20	13.40	13.50	12.30	Dry	19.30	27.45	6.10	••	8.73	4.42		Dry	25. <u>40</u> _	44.10
Water Level Elevation	feet	17.11	17.10	13.75	12.65 0.90	16.69	Dry	19.39	23.55 1.23	22.09	••	17.67	22.64 2.54		Dry ••	27.27 2. <b>3</b> 8	54.38
Casing Volume Volume Purged	gallons	2.82   10.00	1.19	2.71 10.00	5.00	1.26	••	3.50	4.00	4.23 15.00	••	20.00	25.0	••	••	10.00	2.43 10.00
Equivalent Casing Volumes	gallons	1 3.5	8.4	3.7	5.6	11.9		3.8	3.2	3.5		7.5	9.8	••	••	4.2	4.1
General Water Quality	••	(e)	(a)	(a)	(a)	(a)	(a)	(b,c)	(b,c)	(a)		(a)	(a)	••		(b)	(a)
Water Level Elevations	(units)	   MU-1A	MJ-18	 MU-2A		MV-3A	MJ-38	 MV-4	MJ-5	 MV-6	B-7	MV-8	MJ-9	9-10	MW-11	MJ-12	MV-13
				• • • • • • • • • • • • • • • • • • • •	•••••		• • • • • • • • • • • • • • • • • • • •			• • • • • • • • • • • • • • • • • • • •		•••••	•••••				•••••
10/06/87 - Installation 21 to 10/23/87 - Development	feet				13.45	••	••	18.19 19.39	31.15 23.55	20.11	••	16.43	21.23	••	Dry	25.77	53.18
10/28/87	feet feet	17.11	17.10 17.74	13.75 19.21	12.65 18.22	16.69 20.45	20.58	19.90	23.31	22.09 22.14	••	17.67 17.72	22.64 22.82	••	Dry	27.27 27.01	54.38 54.41
11/02/87	feet	13.81		12.03		12.68		17.44	22.18	20.09	••	16.70	21.36		Dry	25.29	52.44
11/06/87	feet	1 16.43	16.52	15.89	14.99	16.61	16.66	17.48	22.17	20.16		16.61	21.38		Dry	25.40	52.66
09 to 11/12/87 - Sampling	feet	16.36	16.10	16.70	17.61	18.29	19.10	17.37	22.20	16.89	•-	16.85	21.41		Dry	25.67	51.35
17 to 12/23/87 - K Testing	feet	16.75	16.95	15.92	14.92	18.51	Dry	18.45	22.55	21.37		17.63	20.82	••	Dry	26.40	51.86
Groundwater Sampling Data	(units)	R⊌-1A	#W-18	MV- ZA	MV-28	MW-3A	Mv-38	16U-4	MJ-5	MW-6	8-7	<b>144-8</b>	HU-9	8-10	MW-11	MV-12	HV-13
Phase I								•••••		• • • • • • • • • • • • • • • • • • • •				••••			
Date Groundwater Sampled		11Nov87	10Nov87	10Nov87	10Nov87	09Nov87	10Nov87	11Nov87	12Nov87	09Nov87		11Hov87	11#ov87			12Nov87	12Nov87
о рн	••	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0		7.0	7.0		••	7.0	7.0
o temperature	Celsius	13.0	13.0	14.5	14.5	18.0	18.0	15.0	15.0	14.5	••	14.5	15.0	••	••	14.0	15.0
o EC	micromhos		8200.0	7500.0	7500.0	17000.0	17000.0	980.0	480.0	650.0	••	11000.0	270.0	••	••	282.0	215.0
o volume water purged	gations	15.0	7.0	18.0	10.0	10.5	2.6	5.0	6.5	18.0	••	14.0	13.0	••		12.0	8.0
o General Water Quality	·•   			···	••	···	••	·-	(d)	···	··	···			 	••	
Phase II	i																
Date Groundwater Sampled	1	190ct88		1900ct88				180ct88					200ct88		•-	180c t 88	130ct88
o pH	1	6.60	6.00	7.17	6.20	6.50	6.90	6.68	6.90	7.20	••	7.00	7.50	••		6.70	6.40
o temperature	Celsius	14.00	14.00	15.50	15.50	17.50	18.00	14.00	14.00	13.00		15.00	20.00	••	••	13.00	14.00
o EC o Dissolved Oxygen	micromhos		11670	14800	6700 3.70	28000 7.00	27400	410.00	490.00	440.00		5260.0	260.00	••	••		350.00
o Salinity	ppm 1	4,80 8.90	4.90 10.00	2.90 9.00	3.70 4.00	7.00 24.00	9.40 25.00	7.40 <.1	6.70 <.1	2.90 0.30		2.70 4.50	2.70 0.20		••	3.20 <.1	5.00
o volume water purged	gallons	8.00	3.00	10.00	7.50	6.00	4.00	5.00	5.00	16.00	••	10.00	8.00	••		10.00	8.00
o General Water Quality	- i	(b)	(a)	(a)	(a)	(b)	(a)	(b)	(b)	(a)		(a)	(c)	••		(b)	(a)
Hydraulic Conductivity (K) Data		169-1A	#W-18	 MW-2A	MV-28	HV-3A	MV-38	MU-4	MV-5	MW-6	B-7	MW-8	MU-9	<b>8-</b> 10	MV-11		MU-13
	i		•••••											•			j
Date of Slug Testing Estimated K - Value	00/00-	170ec87 2.0E-02							23Dec87 2.0E-03		••	18Dec87 1.0E-02		 	••	230ec87 6.0E-03	•
tstimated K * Value	cm/sec																6.1E-W]

#### NOTES:

- A Volclay/Bentonite seal was placed between the bottom of the boring and the sand pack
- 2. a \* Sediment removed, Clear
- 3. b = Sediment removed, water turbid.
- 4. c = Sediment removed, low turbidity.
- 5. BGS = Below Ground Surface
- 6. GS = Ground surface

- 7. TOC = Top of Casing
- 8. -- \* Indicates not available or applicable
- 9. Water Level Elevations are based on City of Tacoma Datum
- Sampling Data for wells 1A, 1B, 2A, 2B, 3A reported for intermediate tide sampling data for well 3b reported for high tide
- Water Level Measurements mode after the sampling dates(after 20 October, 1988) are presented on Table 8-5

ASARCO - REMEDIAL INVESTIGATION BB Table 8-2 Well and Hydrologic Data

PHASE II WELLS		PHASE 11																							
ett & Boring Data \ Nome	(units)	8-14	B- 15		8-17	B-18	B·19	₽-20	0.51	0.55	0-23	8-24	8-25R	B·26	8-27	9-28	8 - 29	B·30	8-31	8-32	8-33		8-35	B · 36	8-37
Date Installed	••	125EP188	13569180	89SEP188	26AUG88	24AUG88	25AUG88	25AUG88	24AUG88	26AUG88	23AUG88	16SEPI	8830AUG88	19AUG58	22AUG88	19AUG88	18AUG88	\$3AUG88	29AUG88	29AUG88	8SEPT88		155EPT88	6SEP188	
Total Boring Depth	feet	74.5	92.0	38.0	68.0	56.5	41.0	16.0	10.5	10.5	24.0	17.5	30.5	43.5	70.0	30.5	31.5	11.5	30.5	11.5	44.5	29.5	47.0	29.5	22.0
op of Screen BGS	feet	67.0		20.2	58.5	43.8	27.7	11.0	5.0	5.5	9.00	• •	12.1	32.8	58.2	20.0	20.5	23.00	17.5	6.5	9.1	9.2	30.8	6.7	9.4
lottom of Screen - BGS	teet	72.0	••	30.2	43.5	54.8	32.7	16.0	15.0	10.5	14.00	• • •	22.1	42.8	68.2	30.0	30.5	33.00	22.5	11.5	19.1	19.7	40.8	16.7	19,4
op of Screen Elevation	feet	-40.1	••	6.1	93.3	107.7	116.7	133.8	146.6	146.2	42.1	••	45.2	60.1	19.0	77.6	72.2	54.6	81.9	92.7	17.1	17.7	-4.8	20.6	15.2
attom of Screen Elevation	feet	-45.1	••	-3.9	88.3	96.7	111.7	128.8	136.6	141.2	37.1	• •	35.2	50.1	9.0	67.6	62.2	44.6	76.9	87.7	7.1	7.2	-14.8	10.6	5.2
asing Size	inches	2.00	••	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
asing Material	type	PVC		PVC	PVE	PVC	PVC	PVC	PVE	PVC	PVC		PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
	ĺ	shed 40	••	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40		shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40	shed 40
icreen Stot Size	inches	0.020		0.020	0.020	0.020	0.020	0.020	0,020	0.020	0.020	• -	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
is Elevation	feet	26.94		26.25	151.61	151.52	144.44	144.60	151.59	151.66	51.11		57.25	92.9	77.22	97.58	92.74	77.55	99.37	99.23	26.2	26.93	26.00	27.33	24.59
IOC Elevation	feet	28.60	••	27.76	153,43	153.21	146.10	146.64	153.14	153.67	53.30	• •	59.77	94.9	78.50	99.51	94.49	79.30	101.68	101.62	27.5	28.94	27.66	28.93	26.33
dell Development Data	(units)	8-14	<b>0</b> ⋅ 15	B·16	8-17	B-18	8-19	B · 20	8-21	B-22	9-53	8-24	a - 25a	0-26	<b>8</b> -27	8-28	8-29	6-30	8-31	g · 32	0-33	8-34	B-35	8-36	8-37
Date Development Completed		88193285	•••	285EP188	275EP18	1827SEP188	275EP188	• • • • • • • • • • • • • • • • • • • •	27SEP18	827 <b>5</b> EP18	8275EP16	A	27SEP188	265EP18	3826SEP188	26SEPT8	8 2656918	826569188	27SEP188	275EP188	28569188	285EP188	285EP188	ZBSEPTBB	285EP188
epth to Water (TOC)	feet	10.00	••	11.77	63.86	39.32	17.43	DRY	11.45	DRY	DRY		7.60	41.6	55,98	DRY	DRY	DRY	10.96	10.97	12.1	11.4	10.62	12.34	10.07
later Level Elevation	feet	18.60		15.99	89.57	113.89	128.67		141.69		••		52.17	53.30	22.52	•-	• •	••	90.72	90.65	15.36	17.11	17.04	16.59	16.26
asing Volume	gallons	10.31		3.23	0.20	2.76	2.74		0.63	••			2.76	0.52	2.19		••		2.24	0.47	1.34	1.60	5.16	0.97	1.79
folume Purged	galtons	45,00		35.00	7.50	15.00	30.00	٠.	0.33	••			20.0	12.0	20.0	••	••	••	20.00	4.0	17.00	10.00	37.00	22.00	10.00
quivalent Casing Volumes		4.4		10.8	36.7	5.4	10.9	••	0.4				7.3	23.1	9.1		• •		8.9	8.5	12.7	6.2	7.2	22.8	5.6
ieneral Water Quality		(b)	••	(b)	(b)	(a)	(b)		(b)	••		••	(b)	(b)	(p)	••	••	••	(c)	(c)	(p)	(a)	(b)	(b)	(4)
Jater Level Elevations	(units)	8-14	B-15	8-16	a-17	B-18	8-19	0.50	0-21	8-55	8-23	B-24	8-25R	B-59	8-27	8-28	8-29	8-30	B-31	0-32	8-33	9-34	<b>8</b> -35	8-36	8-37
8/19 to 9/16/88 - Installation	feet	15.60	• • • • • • • • • • • • • • • • • • •	14.76	96.43	113,21	122.10	· · · · · · · · · · · · · · · · · · ·					46.27		23,50		74.49		85.68	85.62	14.46	18.44	17.66	16.43	17.3
9/26 TO 9/28/88 - Development	feet	18.60		15.99	89.57	113.89	128.68	DRY	141.69	DAY	DEY		52.17	53.30	22.52	DRY	DEY	DRY	90.72	90.65	15.36	17.11	17.04	16.59	
10/5 to 10/6/88 · K lesting	feet	18.60		15.40		113.89	128.60	••	153.14				52.07	53.19	22.56		••		90.55	101.62		12.53	12.88	15.79	
10/13 to 10/20/66 - Sampling	feet	18.76		15.55	89.70	114.08	128.82	DRY	141.78		DRY		51.99	53.13	22.56	DRY	DRY	DRY	91.31	90.90		14.84	15.14	14.19	26.3
Groundwater Sampling Data	(units)	8-14	0-15	B- 16	0-17	B-16	8-19	B - 50	8-21	B-22	8-23	<b>a</b> ⋅ 24	8-25R	B-26	B-27	8-26	0-29	8-30	B-31	0-32	6-35	8-34	B-35	8-36	0-57
late Groundwater Sampled		200ct88	••	190ct68	270ct88	170c158	170ct85						140c t 66	130c t 86	140ct <b>66</b>				170ct88	170ct88	200c168	200c t 88	190ct88	190ct88	190c188
о ри		7.7	••	7.0	8.6	8.2	7.0			••			6.5	6.8	7.0				7.6	7.0	4.9	6.1	7.0	6.7	6.3
o temperatura	Celsius	20.0		18.0	12.0	11.0	16.0	٠.					14.0	14.0	14.0	••			12.0	14.0	16.0	17.0	20.0	17.5	17.0
o EC	micromhos	195.0		1545.0	220.0	360.0	320.0	••			••		390.0	480.0	610.0				1620.0	1570.0	28100.0	19420.0	8500.0	16500.0	3750.0
o 00	ρpm	5.0		6.3	4.6	5.8	7.3						4.4	7.4	5.5				4.7	10.2	6.9	7.6	5.7	6.3	
o satinity	1	0.5		1.0	4.1	0.0	0.0				- •		0.0	0.2	0.0				4.1	1.0		17.0	6.0	9.8	
o volume water purged	gallons	40.0		18.0	10.0	13.0	20.0		•-			••	15.0	2.5	10.0				5.0			5.0	20.0	7.0	
a General Water Quality		(4)	••		(b)	(b)	(0)		••	••		. ••	(b)	(b)	(p)	••	••	••	(4)	(c)	(b)	(4)	(b)	(b)	(b)
Hydraulic Conductivity (K) Data	(units)	8-14   8-14	B-15	8-16	B-17	6-18	8-19	0-50	B-21	0.55	8-23	8.24	8-25R	8-26	B·27	e-28	8-29	g - 30	8-31	B-32	a-33	a-34	B·35	a-36	8-37
Date of Slug Testing		0700188	•••	06OC188		050CT88	0500188	•••	•••		•••		050CTBB		5 OC188				050C188		0600188	060C188	0600188	0600188	0600188

#### MOTES:

- A Voiciay/Bentonite seal was placed between the bottom of the boring and the sand pack
- 2. a = Sediment removed, Clear
- 3. b = Sediment removed, water turbid.
- 4. c = Sediment removed, fow turbidity.
- 5. BGS = Below Ground Surface
- 5. BGS = Below Ground Surface
  6. GS = Ground surface

- 7. TOC = Top of Casing
- 8. -- \* Indicates not available or applicable
- 9. Water Level Elevations are based on City of Tacoma Datum
- 10. Water Level Measurements made after the sampling dates(after
  - 20 October, 1988) are presented on Table 8-5

Table B-2.
Well and Hydrologic Data Phase II Wells

# ASARCO - Remedial Investigation Table B-3 TIDAL CYCLE G.W. SAMPLING

		ļ										PHASE							
Well & Boring Data \ Name	(units)	 	• • • • • • • •	MV-1A	 		MU-18		•••••	MV-2A	 	•••••	MM-58	!		MW-3A	 		₩-3B
Date Installed		 		150ct87	 		150ct87		• • • • • • •	90ct87	 	•••••	120ct87	1		130ct87	1		140ct8
Total Boring Depth	feet	í		25.0	,		15.0	,		31.5	i		20.0	•		21.0	•		13.0
Top of Screen - RGS	feet	i		14.5	•		9.5	•		20.0	•		9.0	•		15.0	,		7.0
Bottom of Screen - BGS	feet	í		24.5	,		14.5	•		30.0	,		19.0	•		20.0	,		12.0
Top of Screen Elevation	feet	i t		8.3	•		13.2	•		4.9	1		16.0	•		11.5	i		19.6
Bottom of Screen Elevation	feet	1		-1.7	•		8.2			-5.1	1		6.0	í		6.5	•		14.6
GS Elevation	feet	] ]		22.77	•		22.69	•		24.93	1 J		24.98	:		26.53	•		26.64
TOC Elevation	feet			24.31	i		24.30	i		27.15	i		26.15	1		28.99	i		29.10
Water Level Data		 	MV-1A	·	 	#W-18		 	 ₩√-2A		 	 MW-28		 	MV-3A	• • • • • • •	j 1	MU-38	
October, 19, 1988	(units)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	OTW(FT)	ELE(FT)	TIME	DTW(FT	ELE(FT)	TIME	DTW(FT)	ELE(FT
LOW TIDE	••••••	0800	11.33	11,44	0800	11.15	11.53	0738	17.30	7.63	0738	17.39	7.59	[ ron	17.00	9.52	LOW	DRY	Dry
INTERMEDIATE TIDE		1130	10.27	12,50	1130	10.35	12.33	MED	14,80	10.13	MED	13.88	11.10	INT	16.87	9.65	ENT	DRY	DRY
TIGH TIDE		1530	8.10	16.21	1530	8.61	14.08	1520	8.76	18.39	1520	8.84	16.14	HIGH	11.21	17.78	HIGH	11.38	17.72
Groundwater Sampling Data	(units)		MV-1A			MH-18			HN-2A	·····	i	MV-28		 	MV-3A		 	MM-38	
LOW TIDE		•••••						 			 		• • • • • • • • • • • • • • • • • • • •	 1			} I		
Date Groundwater Sampled Oct	10 1088	100CT88			і   100СТ84			  100CT&	t		  100CT8			1 100018	A		! !		
o pH	17, 1700	6.5	•	i	5.8	•		7.2			5.6	•		6.7			! !		
o temperature	celsius	17.2			18.8			14.5			15.0			15.3					
o EC	#icromhos			1	10600			13980			10630			31800			, 		
0 00	pom	4.6			4.9			3.0			6.7		1	8.5					_
o salinity	X .	9.0		1	9.8			9.0		í	7.0			25.0					
o volume water purged	gallons	8.0			3.0			10.0		i	5.0			5.0					
INTERMEDIATE TIDE								• • • • • • • • • • • • • • • • • • •		ا ۰۰۰۰۰۰۰	<del></del> -	•••••		 	•••••	•••••	 !	•••••	
Date Groundwater Sampled Oct	19. 1988	1000188	3		1000788	3		1000788	1	i	1000188	3	ľ	100CT8	8				
о рн	-	6.7		i	6.0			6.2		i	7.2		i	6.5					
o temperature	celsius	17.7			18.8			15.5		i	15.5		i	17.5					
o EC	micromhos	10400		i	11670			6700		i	14800		į	28000					
o DO	ppm	4.8		ì	4.9		i	3.7		i	2.9		ì	7.0					
o salinity	<b>x</b>	8.9		i	10.0		1	4.0		i	9.0		i	24.0					
o volume water purged	gallons	8.0		į	3.0		į	7.5		į	10.0		į	6.0			••		
IIGH TIDE	 						•••••			ر ا			······					•••••	
Pete Groundweter Sampled Oct	19, 1988	1000188	1	i	1000788	i	Ì	1000188	i	į	1000188	3	ĺ	100CT8	8		100078	8	
e pH	[	6.6		i	6.0			7.2		j	6.0		į	6.9			6.9		
o temperature	celsius	17.5		İ	18.0			15.0		i	15.0		ĺ	18.0			18.0		
o EC	micromhos	13790		ĺ	11900		·i	18270		i	9320		i	27500			27400		
o DO	ppm	4.3		i	4.4		i	2.4		į	3.1		ĺ	8.9			9.4		
o salinity	x j	9.2		į	9.5		j	12.3		i	5.5		j	25.0			25.0		
o volume water purged	gallons	9.0		i	5.0		i	15.0			5.0		:	10.0			4.0		

#### MOTES

- 1. Bottom of the well is approximately at the bottom of the screen
- A Voiciay/Bentonite seal was placed between the bottom of the boring and the sand pack
- 3. BGS = Below Ground Surface
- 4. GS = Ground surface
- 5. TOC = Top of Casing
- 6. -- \* Indicates not available or applicable
- DTM = Depth to Water below TOC except for readings taken during
   and 28 October, 1987 for which DTW refers to Depth to Water below GS.
- 8. ELE = Elevation Above City of Tacoma Datum
  - (MLLW is approximately 7.6 ft above the City of Tacoma Datum)
- 9. MW-38 Was Dry During Low and Intermediate Tides

J-1824-40
ASARCO - Preliminary Assessment
Table B-4 Well and Water Level Data

		 		STAFF GAGE AT THE									
Well & Boring Data \ Name	(units)	<u>.</u>		BH-1	į		вн-3						
Date Installed				040ct84	 		040ct84			050ct84	 	•	19Jan88
Total Boring Depth	feet	1		38.0	l		33.0			24.5	l		• •
Top of Screen - BGS	feet	1		5.0	]		5.0			5.0	l		
Bottom of Screen - BGS	feet	1		38.0	)		33.0			23.0	)		
Top of Screen Elevation	feet	1		43.8	1		42.0			21.2			••
Bottom of Screen Elevation	feet			10.8	ļ		14.0			3.2			••
GS Elevation	feet	<b>,</b>		48.78	1		46.97			26.23	1		• •
TOC Elevation	feet			50.58			48.72			28.21	 		25.17
Water Level Data			8H-1			BH-2			вн-3			STAFF G	AGE
Date	(units)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT	ELE(FT)	TIME	DTW(FT)	ELE(FT)
1 10 23 October, 1987	feet	 	· · · · · · · · · · · · · · · · · · ·	•			·				 		
23 October, 1987	feet		••		, 								
D2 November, 1987	feet			••	, 	28.90	19.82	10:25	8.55	19.66	·		
06 November, 1987	feet	10:22	28.71	21.87	10:38	28.95	19.77	10:50	8.45	19.76			
09 TO 12 November, 1987	feet			••			·- i						
4 December, 1987	feet	i			i		i		••				
17 TO 23 December, 1987	feet	i	••				i			••			••
29 December, 1987	feet	14:12	26.93	23.65	14:18	28.10	20.62	13:38	7.26	20.95			
14 January, 1988	feet	14:44	27.13	23.45	14:55	28.20	20.52	15:03	7.38	20.83			••
1 January, 1988	feet	09:53	27.35	23.23	09:58	28.20	20.52	09:14	7.43	20.78			
9 January, 1988(High Tide)	feet	06:57	26.90	23.68	06:55	27.88	20.84	06:17	6.85	21.36	06:00	6.25	18.92
9 January, 1988(Intermed. Tide)	feet	19:24	26.81	23.77	19:20	27.88	20.84	18:48	6.88	21.33	18:35	10.85	14.32
O January, 1988(Low Tide)	feet	00:50	26.72	23.86	00:42	27.85	20.87	00:09	6.81	21.40	00:00	22.15	3.02
25 January.1988	feet	16:40	26.56	24 02	14-45	27 94	20.78	15:59	7.07	21.14	15:41	18.10	7.07

#### NOTES:

- 1. Bottom of the well is approximately at the bottom of the screen
- A Volclay/Bentonite seal was placed between the bottom of the boring and the sand pack
- 3. BGS = Below Ground Surface
- 4. GS = Ground surface
- 5. TOC = Top of Casing
- 6. -- = Indicates not available or applicable
- 7. DTW = Depth to Water below TOC except for readings taken during 21 and 28 October, 1987 for which DTW refers to Depth to Water below GS.
- 8. ELE = Elevation Above City of Tacoma Datum
  (MLLW is approximately 7.6 ft above the City of Tacoma Datum)

ASARCO - Remedial Investigation
Table B-4 Well and Water Level Data

					1					1		PHASE I										
Well & Boring Data \ Name	(units)			MW- 1A			MW- 18			MW-ZA			MM-58			MW-3A			MW-38			MU-4
Date Installed	·	••		150ct87			150ct87	 	• • • • • • • •	90ct87			120ct87			130ct87	• 		140ct87		•••••	10ct8
Total Boring Depth	feet			25.0	i		15.0	i		31.5			20.0			21.0	i		13.0			34.0
op of Screen - BGS	feet			14.5	•		9.5	i		20.0			9.0			15.0	•		7.0	i I		15.0
ottom of Screen - BGS	feet			24.5	•		14.5	i		30.0			19.0			20.0	•		12.0			25.
op of Screen Elevation	feet			8.3	•		13.2	i		4.9			16.0			11.5	i		19.6			22.
ottom of Screen Elevation	feet			-1.7	i		8.2	i		·5.1			6.0			6.5	i		14.6			12.0
S Elevation	feet			22.77	i		22.69	i		24.93			24.98			26.53	i		26.64			36.9
OC Elevation	feet			24.31	į		24.30	į		27.15			26.15			28.99	į		29.10	٠		38.6
ater Level Data	· · · · · · · · · · · · · · · · · · ·		MW-1A	•••••	] I	MW- 18		 	MW-ZA		 	MV-2B			MU-3A	••••	 	MM-38	•••••		MW-4	
ate	(units)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TEME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	)ELE(F1
21 TO 23 October, 1987	feet	13:20	7.20	15.57	13:30	7,20	15.49	   12:00	13.40	11.53	 	13.50	11.48		12.30	14.22	 	Dry	Dry		19,30	17.6
8 October, 1987	feet	15:30	6.56	16.21	15:31	6.56	16.13	15:01	7.94	16.99	15:03	7.93	17.05	13:00	8.54	17.99	13:05	8.52	18.12	12:00	18.79	18.1
2 November, 1987	feet	10:51	10.50	13.81	i	•-		10:40	15.12	12.03	í		}	10:10	16.30	12.68	i	• •		•	21.25	17.4
6 November, 1987	feet	11:10	7.88	16.43	11:15	7.78	16.52	11:03	11.26	15.89	11:04	11.16	14.99	10:41	12.38	16.61	10:44	12.44	16.66	10:46	21.21	17.4
9 10 12 November, 1987	feet		7.95	16.36	i	8.20	16.10	i	10.45	16.70		8.54	17.61		10.70	18.29	i	10.00	19.10	i	21.32	17.3
4 December,1987	feet	13:32	6.56	17.75	13:31	6.77	17.53	13:39	8.31	18.84	13:41	8.62	17.53	13:07	10.78	18.21	13:05	10.57	18.53	12:58	19.92	18.7
7 TO 23 December, 1987	feet	12:05	7.56	16.75	12:07	7.35	16.95	09:36	11.23	15.92	09:37	11.23	14.92	10:33	10.48	18.51	·	Dry		12:17	20.24	18.4
9 December, 1987	feet	13:17	5.96	18.35	13:18	5.99	18.31	13:24	7.82	19.33	13:25	7.80	18.35	13:30	9.80	19.19	13:31	9.95	19.15	14:22	20.42	18.2
4 January,1988	feet	14:14	7.38	16.93	14:15	7.23	17.07	14:20	10.20	16.95	14:21	10.24	15.91	14:26	12.14	16.85	14:27	12.26	16.84	14;59	20.40	18.2
1 January, 1988	feet	08:42	7.14	17.17	08:43	7.23	17.07	08:53	8.13	19.02	08:55	8.16	17.99	09:02	10.95	18.04	09:05	10.10	19.00	10:03	20.50	18.1
9 January,1988(High Tide)	feet	06:31	7.88	16.43	06:33	8.30	16.00	06:27	8.31	18.84	06:25	8.50	17.65	06:09	12.18	16.81	06:10	11.94	17.16	06:48	19.81	18.8
9 January,1988(Intermed. Tide)	feet	19:01	6.40	17.91	19:02	6.05	18.25	18:51	9.56	17.59	18:53	9.45	16.70	18:42	10.76	18.23	18:40	10.85	18.25	19:18	19.68	19.0
0 January, 1988(Low Tide)	feet	00:24	11.06	13.25	00:22	10.94	13.36	00:16	19.30	7.85	00:17	19.36	6.79	00:04	16.50	12.49	00:04	Dry	••	00:39	19.82	18.8
5 January,1988	feet	16:11	9.57	14.74	i 16:12	9.10	15.20	1 16:03	14.98	12.17	16:05	14.89	11.25	15:52	14.68	14.31	1 15.53	Dry		16:49	20.33	18.3

#### NOTES:

- 1. Bottom of the well is approximately at the bottom of the screen
- A Voiciay/Bentonite seal was placed between the bottom of the boring and the sand pack
- 3. BGS = Below Ground Surface
- 4. GS = Ground surface
- 5. TOC \* Top of Casing

- 6. -- = Indicates not available or applicable
- 7. DTW = Depth to Water below TOC except for readings taken during 21 and 28 October, 1987 for which DTW refers to Depth to Water below GS.
- 8. ELE = Elevation Above City of Tacoma Datum
  (MLLW is approximately 7.6 ft above the City of Tacoma Datum)

Table B-4. Well and Water Level Data (Continued)

ASARCO - Remedial Investigation
Table B-4 Well and Water Level Data

	 	 					· · · · · · · · ·		• • • • • • •			PHASE I		· • ·		• • • • • • •	• • • • • • • •			• • • • • • •		
Well & Boring Data \ Name	(units)			NW-5	! !	• • • • • • • •	MW-6	 	••••	MW-8			MM-8	 	•••••	MW-11	 		MW-12			MV-13
Date Installed		 		30Sep87	 		50ct87	 	••••	20ct87	!	•••••	285ep87	 	• • • • • • • •	21Sep87	 		24Sep87	• • • • • • • • • • • • • • • • • • •		23Sep87
Total Boring Depth	feet	i		69.5	i		42.5	i		35.0			36.5	į		36.5	i		45.0			76.0
Top of Screen - BGS	feet	i		25.0	i		27.0	i		15.0			10.0	i		11.0	i		30.0	ĺ		49.0
Bottom of Screen - BGS	feet	i		35.0	i		32.0	i		25.0			20.0	i		16.0	i		40.0			59.0
Top of Screen Elevation	feet	i		23.8	i		-0.8	i		10.1			15.6	i		139.3	i		21.2	į		48.5
Bottom of Screen Elevation	feet	i		13.8	•		-5.8	i		0.1			5.6	i		134.3	i		11.2	i		38.5
GS Elevation	feet	i		48.80	i		26.24	i		25.08			25.64	i		150.26	i		51.16	i		97.49
TOC Elevation	feet	į		50.11	į		28.19	•		26.40			27.06	į		152.06	i		52.67	i		98.45
Water Level Data		 	MW-5		 	MV-6		} 	MW-8		<b></b>	MW-9	•••••	 	MW-11		} 	MW-12	• • • • • • • • • • • • • • • • • • • •	* * * · 	MW-13	
Date	(units)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	TIME	OTW(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)
21 TO 23 October, 1987	feet	 	27.45	21.35	 	6.10	20.14	 	8.73	16.35	14:10	4.42	21.22	 	Dry	••••	 	25.45	25.71		44.10	53.39
28 October, 1987	feet	:		21.11	•		20.19	•		16.40	•		21.40	i	. •		•		25.50			
02 November, 1987	feet	•		21.28	•		20.09	•		16.70	,		21,36	i	Dry				25.29	•	46.04	
06 November, 1987	feet	:		21.28	•		20.16	11:21	9.79	16.61	11:23	5.68	21.38	i	Dry		10:28	27.26	25.40	09:50	45.82	52.63
09 TO 12 November, 1987	feet	·	28.80	21.30			16.89	•		16.85	i	5.65	21.41	i	Dry		,		25.67	•	47.13	
14 December, 1987	feet	12:54	28.00	22.10	•		21.49	•	8.45	17.95	13:23	5.11	21.95	i	Dгy		12:20	25.82	26.85	12:01	45.95	52.50
17 10 23 December, 1987	feet	11:42	28.45	21.65	11:09		21.37	:		17.63	09:50	6.24	20.82	i	Огу		•		26.40	•		
29 December, 1987	feet	14:15	28.05	22.05	13:36	7.05	21.14	13:44	9.04	17.36	13:48	6.45	20.61	i	Dry		:		26.77	•		
04 January, 1988	feat	14:49	28.06	22.04	14:31	7.15	21.04	14:36	9.00	17.40	14:40	6.85	20.21	i	Dry		15:09	26.08	26.59	15:13	46.05	52.40
11 January, 1988	feet	09:55	28.15	21.96	09:15		21.14	•		17.50	09:28	6.92	20.14	i	DLA		09:48		26.46			
19 January, 1988(High Tide)	feet			22.08	•		21.34	•			•		21.51	i	Dry		•		26.13	•		
19 January, 1988(Intermed, Tide)	feet			22.10			21.34	•		18.33	•		21.46	i			•		26.35			
20 January, 1988(Low Tide)	feet	:		22.10	•		21.17	•			•	5.53	21.53	i			•		26.51	•		
25 January, 1988	feet			22.19			21.03	•		17.44	•	5.95	21.11	j	-	••	•		26.65	•		
					1	• • • • • • •		1	• • • • • • •			• • • • • • •		1	· · · · · · · ·		1		• • • • • • •	J		·

#### NOTES

- 1. Bottom of the well is approximately at the bottom of the screen
- A Volclay/Bentonite seal was placed between the bottom of the boring and the sand pack
- 3. BGS = Below Ground Surface
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- 6. -- = Indicates not available or applicable
- DTW = Depth to Water below TOC except for readings taken during
   and 28 October, 1987 for which DTW refers to Depth to Water below GS.
- 8. ELE = Elevation Above City of Tacoma Datum
  (MLLW is approximately 7.6 ft above the City of Tacoma Datum)

Table B-4.
Well and Water Level Data (Continued)

ASARCO - Remedial Investigation Table 8-5 Well and Water Level Data

	i											PHASE I	ı																		
		<b></b> .	<b></b>					1	. <b></b>		ļ <b>.</b>								1			. <b></b>	j				• • • • • • • • •	/	J		
li & Boring Date \ Mame	(units)			MU-1A	į		HU-18	:		MW-ZA	į		MV-28	į		MU-3A			HN 38			MJ-4	į		MW-5	į		MV-6	İ		MW - 8
te Installed				50ct87	1		150c t 87			90ct87	!		120c t 87			130ct67			40c t87			10c t 87	!	:	30sep87	•		50c t 87	!		20c t l
tal Boring Depth	feet			25.0	1		15.0	1		31,5	ĺ		20.0	ı		21.0	1		13.0			34.0	1		69.5	i		42.5	ı		35.0
p of Screen - BGS	feet			14.5	ı		9.5	1		20.0	1		9.0	l		15.0	l		7.0			15.0	İ		25.0	I		27.0	1		15.0
ttom of Screen · BGS	feet			24.5	l		14.5	1		30.0	ı		19.0	l		20.0	1		12.0			25.0	1		35.0	1		32.0	ŧ		25.0
of Screen Elevation	feet			8.2	ł		13.1	İ		4.9	ĺ		15.9	1		11.4	١		19.5	1		21.9	İ		23.7	i		.1.0	1		10.0
tom of Screen Elevation	feet			-1.8	1		6.1	i		-5.1	1		5.9	1		6.4	1		14.5	1		11.9	1		13.6	1		-6.0	l .		0.
Elevation	feet			22.71	l		22.61	1		24.86	i		24.90	l		26.40	l		26.48	1		36.93	1		48.65	i		26.03	ł .		25.0
Elevation	feet			24.24	!		24.13	!		27.08	!		27.06	!		28.64			28.94			38.54	!		49.96	ļ		27.99	!		26.42
ter Level Data		••••	MU-1A	•••••		MU-18		1	MN-SV	• • • • • •	1	MU-28			MU-SA		• • • • • • • • • • • • • • • • • • •	MV-38			MV-4			RU-5	•••••	 	MV-6		] [	MV-8	
t•	(units)		DIW(FF)		TIME	DIW(FI)	ELE(FT)	TIME		LE(FT)	:			:						TIME	DIV(FT)E	ELE(FT)	:			:	DTW(FT)	ELE(FT)	TIME	DTV(FT)	ELE (F
t. 13 to Oct 20 Sampling	feet				 			.   			 			] 	•••	•••	] • • • • • • • • • • • • • • • • • • •				21.19	15.74		29.02			7.69	20.30		10.03	16.39
. 19 Low Tide	feet	6:004	11.33	12.91	8:00a	11.15	12.98	8:340	16.93	10.15	7:40	17.39	9.67	· · ·	17.46	11.38	·	14.70	14.24	09:28a	21.33	15.60	9:30a	28.93	21.03	9:17a	7.86	20.13	i ··		-
19 Hedium Tide	feet	11:00e	10.27	13.97	11:00a	10.35	13.78	   11:55a	12.20	14.88	11:554	12.67	14.39	i	16.87	11.97	· · ·	14.71	14.23	12:15p	21.43	17.11	12:20p	28.91	21.05	12:05p	7.81	20.18	3:03r	9.95	16.4
. 19 High Tide	feet	2:300	8,10	16.14	2:30p	8.61	15.52	3:20p	8.76	18.32	3:200	8.84	18.22	į	11.21	17.63		11.38	17.56	5:10p	21.39	17.15	5:05p	29.00	20.96	6:45p	7.83	20.16	4:456	9.98	16.4
. 27 Water Levels	feet	2:280	8.21	16.03	2:27p	7.96	16.17	2:16p	11.57	15.51	2:15	11.52	15.54	1:41p	12.97	15.87	1:40p	13.13	15.81	1:25p	21.30	17.24	1:23p	26.63	21.13	2:08p	7.94	20.05	2:34	10.00	16.4
. 2 Water Levels	feet	9:14:	9.94	14.30	9:16a	10.02	14.11	9:394	12.87	14.21	9:43	13.10	13.96	9:50	15.83	13.01	9:53e	DAY	DRY	10:220	21.16	17.38	10:27	28.73	21.23	10:08a	7,71	20.28	9:33	9.66	16.
, 10 High Tide	feet	5:03p	6.25	17.99	5:02p	6.25	17.68	4:54p	8.23	16.65	4:54p	8.50	18.56	4:18p	11.00	17.84	4:17p	11.16	17.78	5:26p	20.72	17.82	5:30p	28.76	21.20	1 4:34p	8.25	19.74	5:13r	8.65	17.7
, 10 Intermediate Tide	feet	8:19p	8.62	15.62	8:19p	7.09	17.04	8:10p	11.81	15.27	6:10p	11.50	15.56	7:44p	11,90	16.94	7:47p	12.10	16.84	8:45p	20.81	17.73	9:00p	28.60	21.36	8:03p	7.22	20.77	8:35g	8.71	17.7
. 10 Low Tide	feet	11:56	10.53	13.71	11:57p	9.89	14.24	11:52p	17.66	9.42	[11:51p	17.39	9.67	11:30p	15.86	12.98	11:30p	14.66	14.28	12:40	20.08	18,46	11:45	28.62	21.34	11:40p	7.27	20.72	12:10/	6.71	17.1
. 16 Weter Levels	feet	12:19;	6.45	17.79	12:18p	6.94	17.19	12:260	7.54	19.54	12:27p	7.64	19.42	12:37p	9.90	18.94	12:35p	10.07	18.87	11:57a	20.70	17.84	[11:48e	28.35	21.61	12:55p	7.02	20.97	12:01¢	6.71	17.7
, 22 Water Levels	feet		6.98	17.26	1	6.92	17.21	1	10.57	16.51	1	10.59	16.47	٠٠٠ ا	DRY	DRY		DRY	DRY	1	20.46	15.08	11:30a	28.21	21.75		6.70	21.29	1	8.68	17.7
. 1 Water Levels	feet	10:58	7,80	16.44	10:56a	8.58	15.55	j11:15e	8.39	18.69	10:10:	8.69	18.37	11:40e	11.14	17.70	11:34e	10.77	18.17	12:06p	20.23	18.31	112:08	28.02	21.94	11:55e	6.54	21.45	11:05	8.49	17.9
. 7 Water Levels	feet	9:40	7.72	16.52	9:350	7.70	16.43	9:224	10.01	17.07	9:24	10.02	17.04	9:120	11.67	17.17	9:05a	11.71	17.23	10 : 30a	20.67	17.87	10:364	28.23	21.73	10:220	7.14	20.85	10:11	9.13	17.2
. 15 Water Levels	feet	10:30	8.62	15.62	10:350	9.18	14.95	10:20e	9,11	17.97	10:25	9.35	17.71	10:05e	12.77	16.07	10:10a	DRY	DRY	11:35a	20.90	17.64	11:40	28.35	21.61	11:05+	7.42	20.57	11:00	9.44	16.9
. 22 Water Levels	feet	10:50	6.43	17.81	10:35	6.24	17.89	10:20	9.30	17.78	10:15	9.20	17.86	9:25.	10,49	18.35	9:30a	10.67	18.27	11:35	20.62	17.92	11:454	28.29	21.67	10:05	7.26	20.73	111:10	9.02	17.4
. 29 Vater Lavels	feet	11:10	7,40	16.84	11:150	7.90	16.23	10:40	8.05	19.03	110:45	8.38	18.66	9:55a	11.85	16.99	10:00e	11.82	17.12	12:00p	20.74	17.80	12:25	28.24	21.72	10:30e	7.25	20.74	10:55	9.07	17.3
. 5 Water Levels	feet	9:45	10.76	13.48	9:45p	10.06	14.07	9:22p	17.46	9.62	9:25	p 17.19	9.87	8:54p	15.60	13.24	8:55p	14.65	14.29	8:54p	20.31	18.23	8:25	28.06	21.90	9:15p	7.12	20.87	9:32	p 8.69	17.7
. 5 FLEXIDIP Probe oil dete	ected		- MO		1	- NO		1	- 40		1	-100		1	- 100		ı	- 80		ı			i	••		1			I .	- 80	
.,					•			,			•						•			•			•			•			•		

MOTES:

 A Voiclay/Bentonite seal was placed between the bottom of the boring and the sand pack

2. BGS \* Below Ground Surface

3. GS = Ground surface

4. TOC + Top of Easing

5. -- = Indicates not available or applicable

6. ELE = Elevation Above City of Facoma Datum

(MLLW is approximately 7.6 ft above the City of Tacoma Datum)

7. a = am, p = pm

8. DIW for B-35 Nov. 10, Intermediate tide and low tide based on tranducer data

ASARCO - Remediat Investigation lable 8-5 Well and Water Level Data

		 				1			1			· · · · · · · · · ·			1		1			1			1		PHASE I				
ell & Boring Data \ Hame	(units)				Hu-9	[		HM-11	1		MM-12			RM-13			B-14			15		8-	16			B-17			8-18
te Installed	••	 	•••••		85ep87	'l		21\$ep87	1		245ep87	l		235ep87	] ]	1	2SEP18		139	EPTB		956	P188			26AUG88			24AUG88
otal Boring Depth	feet	i			36.5	i		34.5	ı		45.0	1		76.0	l		74.5		•	2.0		3	8.0			68.0			54.5
op of Screen - BGS	feet	1			10.0	1		11.0	1		30.0	l		49.0	ı		67.0			٠٠ ا		2:	2.0			59.0			44.5
ttom of Screen - BGS	feet	i			20.0	1		16.0	I		40.0	l .		59.0	ı		72.0			1		3.	2.0			64.0			55.5
of Screen Elevation	feet	1			15.5	i		139.2	1		21.0	1		48.4	1		-40.1			· · i			4.3 1			92.6			107.0
tom of Screen Elevation	feet	l .			5.5	i		134.2	ı		11.0	t		38.4	l		-45.1 ]						5.8			87.8			96.0
Elevation	feet	ı			25.54	1		150.22	1		51.02	l		97.41	ı		26.94					26	.25			151.81			151.52
CELEVATION	feet				26.95	1		152.04	ļ		52.53	!		98.39	!		28.60			·· į		27	.76			153,43			153.21
iter Level Data		• • • • • • • • • • • • • • • • • • •	PR-/			1	M/- 1	1	1	Mv-12		1	MV-13		( (	6-14	1		<b>a</b> -15	ı	• • • • • •	6· 16	1		6-17			6-18	
ste	(units)	TIME	DIV	(FT)E	LE(f1)	TIME	DIMEL	)ELE(FI)	TIME	DIW(#1	ELE(FT)	TIME	DIW(FI	)ELE(f1)	TIME	DIW(FT)	LE(FT)	TIME	DIW(FT)ELE	(f1)	TIME	DIW(FI)ELE	(FT)	TIRE	DIMCFI	ELE(FT)	TIME	DIW(FT)	ELE(FT)
t. 13 to Oct 20 Sampling	feet	2:10	p 8	.51	18.44				ί	27.00	25.53		56.72	41.67	1   3:35p	10.10	18.50	٠.		¦	3:15p	11.98 15	.78		63.73	89.70		39.13	114,08
t. 19 Low Tide	feet	١,				i -			9:35a	27.15	25.38	i		98.39		9.89	18.71		••	···j	••	• •						••	
19 Nedium Tide	fest	3:00	p 8	. 19	16.76	1 -			112:30a	27.18	25.35	10:254	46.96	51.45			1		••	(	09.45	12.25 15	.51 (	10:00a	64.07	89.36	10:07a	59.18	114.0
. 19 High Tide	feet	6:34	ρ 8	. 16	18.77	į ·			7:00p	27.50	25.03	i					1	٠- ا	•-	· · i	3:45p	12.21 15	.55						
. 27 Water Levels	feet	2:40	p 8	.40	18.55	111:20	DRY	DRY	1:15p	26.84	25.69	1:00p	46.75	51.64	2:03p	9.62	18.78			j	2:30p	11.99 15	.77 j	9:30e	63.62	89.61	11:30a	39.10	114.1
. 2 Water Levels	feat	9:09	. 8	. 23	18.72	12:32	DRY	DRY	10:30e	26.46	26.07	11:18e	46.38	52.01	10:00a	9.59	19.01	٠٠.	••	· · j	9:23a	11.97 15	.79	12:14p	63.68	89.75	12:04p	38.80	114.4
r. 10 High Tide	fest	5:15	6 9	.60	20.35	i -	- DRY	DRY	5:32p	26.83	25.70	į			4:17p	8.45	20.15	i	••	j	5:03p	10.57 17	. 19	5:57p	63.52	89.91	5:51p	38.64	114.5
, 10 Intermediate Fide	feet	0:31	p 6	.59	20.36	į ·			9:05p	26.61	25.92	9:30p	46.97	51.42	8:00p	8.61	19.99	· ·		· · · i	8:23p	10.63 17	.13						
. 10 Low Tide	feet	12:30	a 6	.57	20.38	į ·			12:47	26.73	25.80	i			11:36p	6.98	19.62	· ·			11:45p	10.93 16	.83				i		
, 16 Water Levels	feet	12:05	p 6	. 37	20.58	110:37	. 081	DRT	j11:44e	26.24	26.29	111:154	46.82	\$1.57	12:43p	9.29	19.31	j		j	12:18p	11.12 16	أ عه.	10:40a	63.10	90.33	10:260	36.49	114.77
. 22 Unter Levels	feet		5	.74	21.21	1 .	- DRY	DRY	1	12.65	39.66	1	46.21	52.18		9.85	18.75		••		12:18p	10.54 17	.22		62.66	90.77		38.60	114.61
. 1 Water Levels	feet	11:07	. 5	.54	21.41	9:51	DAY	DRY	111:58a	25.52	27.01	10:314	46.82	51.57	11:458	9.41	19.19		••	1	10:45	11.30 16	.46	9:48a	62.72	90.71	10:03.	38.28	114.9
. 7 Water Levels	fest	10:29	. 6	. 26	20.69	1:55	-	DRT	12:05p	25.95	26.56	11:25	47.08	\$1.31	6:55a	9.62	18.78	· ·	• •	·- i	9:464	11.61 16	. 15	2:05p	62.85	90.58	1:50p	38.43	114.78
. 15 Water Levels	feet	10:55	. 6	. 80	20.15	1 2:20	DAY	DRY	112:05p	26.29	26.24	12:200	47.23	51.16	11:206	10.30	18.30	i		j	10:40e	12.03 15	.nai	2:25p	62.88	90.55	2:100	38.60	114.61
. 22 Water Levels	feet	11:05	. 6	.62	20.15	2:10	D DRY	DRY	112:00p	25.80	26.73	12:200	46.46	51.93	9:50a	9.31	19.29	i		1	10:45a	11.13 16	.63 أ	2:25p	63.17	90.26	2:05p	38.39	114.8
. 29 Mater Levels	feat	11:00	)a 6	. 69	20.26	1 1:50	D ORY	DRY	112:35p	26.00	26.53	12:50p	46.70	51.69	10:15a	9.87	18.73	·				11,59 16					2:00p		
n. 5 Water Levels	feet	9:39	p 5	.93	21.02	i -	- DRY	DRY	10:10p	25.87	26.66	8:17	46.73	51.66	9:50p	9.05	19.55	· · ·				11.13 14					7:28p		114.64
. S FLEXIDIP Probe oil dete	Della	i		- 100		i			i			ì			i '		i	i		i		••	- 1						, -
n. 24 Mater Levels	feet	11:00		. 00	20.95	1 2:40		PRC	111.44.	34 OA	24 55			51.51	. 0.30-	9.82	18.78				10.40-	11,40 16		3.36-	43.13	01 01	2:15p	38.27	114.94

#### NOTES:

 A Volclay/Bentonite seal was placed between the bottom of the boring and the sand pack

2. BGS - Below Ground Surface

3. GS = Ground surface

L. 10C = 10p of Casing

5. -- \* indicates not available or applicable

6. ELE . Elevation Above City of Tacoma Datum

(MLLW is approximately 7.6 ft above the City of Tacoma Datum)

7. s \* ana, p \* pm

8. DIW for 8-35 Nov. 10, Intermediate tide and low tide based on tranducer data

ASARCO - Remedial Investigation Table 8-5 Well and Water Level Data

	!												1					PHASE II	1			
ell & Boring Date \ #ame	(units)			0 · 26			9-27			8-28			B-29			0-30			0-31			8 - 32
ate Installed				19AUG88	•••••		22AUG88			19AUG88			18AUG88			23AUG88			29AUG88			29AUG86
otal Boring Depth	feet			43.5			70.0			30.5			31.5			11.5			30.5			11.5
op of Screen - BGS	feet			33.0			57.0			20.0			20.5			23.0			17.5			6.
ottom of Screen - BGS	feet			43.0			67.0			30.0			30.5			33.0	}		22.5			11.
op of Screen Elevation	feet			59.9 [			20.2			77.6	!		72.2			54.6	1		81.9			92.
ottom of Screen Elevation	feet			49.9			10.2			67.6	1		62.2			44.6	l		76.9			87.
S Elevation	feet			92.90			77.22			97.58	1		92.74			77.55	1		99.4			99.2
OC Elevation	feet	·		94.87			78.50			99.51	) 		94.5			79.30	 		101.7			101.6
later Level Data			● · 26	i		8-27	i		0 - 28	ľ		9 - 29	j		9 - 30	j	İ	B-31	i		0 - 32	
ate	(units)	TIME	OTW(FT)	ELE(FT)	TIME	DIW(FI)	ELE(FT)	TIME	DIW(FF)	ELE(FT)	TEME	DTW(FT)	ELE(FT)	TIME	OTV(FT)	ELE(FT)	TIME	DTW(FT)	ELE(FT)	FIME	Ofu(Ff)	ELE(FT)
et. 13 to Oct 20 Sampling	feet		41.74	53.13		55.94	22.56		DRY	DRY		DRY	DRY		DRY	DRY		10.37	91.31		10.72	90.90
t, 19 Low Tide	feet			[		••	i	••	••	(	٠- ا					••	9:45a	10.25	91.43	9:47a	10.00	91.6
t 19 Medium Tide	feet	10:35a	42.09		10:39e	56.12	22.38		DRT	DRY		DRY	DRY	10:40a	DRY	DRY		••	1	••	••	
t. 19 High Tide	feet			1		••	[						1						1		••	
t. 27 Water Levels	feet	12:45p	42.10	52.77	12:35p	57.37	21.13	1:00p	DRY	DRY	12:45p	DRY	DRY	12:35p	DRY	DRY	11:20a	10.38	91.30	11:25a	10.65	90.9
ov. 2 Water Levels	feet	11:03a	42.03	52.84	10:50a	55.79	22.71	11:11a	DRY	DRY	11:10e	DRT	DRY	10:54a	DRY	DAY	12:28p	10,00	91.68	12:26p	10.37	91.2
ov. 10 High Tide	feat	٠٠ ا	••	1			}	••	• •	(			1	••	••	••	6:05p	8.51	93.17	6:03p	B.56	93.0
ov. 10 Intermediate Tide	feet	9:35p	41.99	52.88	9:38p	56.31	22.19	9:30p	DRY	DRY	9:34p	DRY	DRY	9:10p	DAY	DRY			1			-
ov. 10 Low 1 ide	feet			1			1	••				••		••				••	1	••	••	•
ov. 16 Water Levels	fest	11:10e	42.04	52.83	11:00a	55.78	22.72	11:140	DRY	DRY	11:11a	DRY	DRY	11:02a	DRY	DRY	10:45a	8.48	93.20	10:47	7.71	93.9
ov. 22 Water Levels	feet		41,99	52.88		56.55	21.95		DRY	DRY	٠٠ ا	DRY	DRY		DRY	DRY	٠٠ ا		1			
ec. 1 Water Levels	fest	10:25a	42.00	52.87	10:37a	55.60	22.90	10:284	32.20	67.31	10:20e	DRY	DRY	10:32	DRY	DSA	9:41a	6.86	92.82	9:40a	7.93	93.6
ec, 7 Water Levela	feet	11:40a	42.11	52.76	11:55a	55.65	22.85	11:35a	DRY	DRY	11:37e	DRY	DRY	11:58a	DRY	DRY	2:05p	9.10	92.58	2:10p	8.53	93.0
c. 15 Water Levels	feet	12:30p	42.15	52.72	12:40p	55.69	22.81	12:25p	DRY	DRY	12:35p	DRT	DRY	12:45p	DAY	DRY	2:40p	9.48	92.20	2:35p	8.79	92.8
ic. 22 Water Levels	feet	12:40p	42.11	52.76	12:45p	55,57	22.93	12:25p	31.86	67.65	12:35p	DRY	DRY	12:50p	DRY	ORY	2:35p	9.01	92.67	2:40p	8.66	92.9
ec. 29 Water Levels	feet	1:00p	42.13	52.74	1:10p	55.47	23.03	12:55p	31.92	67.59	1:05p	ORY	DRY	1:15p	DRY	ORY	2:35p	9.37	92.31	2:30p	8.39	93.2
en. 5 Water Levels	feet	8:70p	41.94	52.93	8:04p	55.60	22.90	8:15p	31.69	67.82	6:10p	DRY	DRY	8:08p	34.22	45.08	7:17p	8.97	92.71	7:15p	8.06	93.5
m, 5 FLEXIDIP Probe oil det	tected	l					1			1	1	••			••		1	••	- 1	i	••	
an, 24 Water Levels	feet	1:20p	42.10	52.77	1:35p	55.51	22.99	1:10p	31.63	67.88	1:25p	DRY	DRY	1:40p	34.21	45.09	2:50p	9.14	92.54	2:55p	8.25	93.3

#### NOTES:

 A Volcisy/Bentonite seal was placed between the bottom of the boring and the send pack

- 2. BGS = Below Ground Surface
- 3. GS = Ground surface
- 4. TOC = Top of Casing
- 5. -- \* Indicates not available or applicable
- 6. ELE Elevation Above City of Tacoma Datum

(MLLW is approximately 7.6 ft above the City of Tacoma Datum)

- 7. a + an, p + pn
- 8. DIW for 8-35 Mov. 10, Intermediate tide and low tide based on transucer data

Table B-5. Well and Water Level Data (Continued)

ASARCO - Remedial Investigation Table 8-5 - Well and Water Level Data

		,																PHASE II				
eli & Boring Data \ Hame	(units)	İ		8-19			B-20			8-21			8-22	i		8-23			6·24			6·25
ate installed	•••	· · · · · · · · · · · · · · · · · · ·		25AUG88			25AUG88 [			24AUG88			Seauges i	 		23AUG88			16SEP188			30AUG88
otal Boring Depth	feel	i		41.0			16.0			10.5	ı		10.5	i		24.0			17.5			38.5
op of Screen • BGS	feet	i		29.0			11.0			5.0			5.5	i		9.0 j			i			12.5
attam of Screen - BGS	feet	i		34.0			16.0			15.0			10.5	i		16.0			[			22.5
op of Screen Elevation	feet	i		115.4			133.8			146.6			146.2	ĺ		42.1 [			[			44.8
attem of Screen Elevation	feet	ĺ		110.4			128.8			136.6			141.2	ļ		37.1			[			34.6
S Elevation	feet	ĺ		144.44			144.80			151.59			151.66	ı		51.11			(			57.25
OC Elevation	feet	1		146.10			146.64			153.14			153.64	!		53.30			[			59.77
ater Level Data		· · · · · · · · · · · · · · · · · · ·	a-19		• • • • • • • • •	B-20	اا		B-21			B-22	· · · · · · · · · · · · · · · · · · ·	, I	8-23			8-24			B- 25	
ate	(units)	TIME	DIW(FI)	ELE(FT)	TIME	DTW(FT)	ELECTT)	TIME		ELE(FT)			ELE(FI)	TIME	DIW(FI)	ELECTT)	TIME	DIW(FT)	ELE(FT)	TIME	DIW(FT)	ELE(FT)
ct. 13 to Oct 20 Sampling	feet	·········	17.28	128.82		DRY	DRY	3:35p	11.36	141.78	••			l				•••			7.78	51.99
ct. 19 Low Tide	feet	·			٠.									i		i				••		
ct 19 Medium Tide	feet	10:05=	17.23	128.67	10:02=	DRY	DRY	10:10a	11.38	141.76			i	i		i			]	10:25a	7.15	52.62
ct. 19 High Tide	feet						·• ì			1				· ·					••			
ct. 27 Water Levels	feet	11:32a	11.57	134.53	11:35	DRY	DRY	11:32a	11.57	141.57	11:15a	DRY	DRY	1:17p	DRY	DRY			•• [	12:25p	12.55	47.22
ov. 2 Water Levels	feet	12:02p	17.33	128.77	12:00p	DRY	DRY	12:07p	11.32	141.82	12:14p	DRT	DRY	12:40p	DRY	DAY				••		
ov. 10 High Tide	feet	5:46p	16.81	129.29		DRY	DRY	5:54p	10.83	142.31	5:57p	DRY	DRY	5:34p	DRY	DRY						
ov. 10 Intermediate fide	feet					••		• • •			٠٠.	DRY	DRY			[				9:50p	6.23	53.54
ov. 10 Low Fide	feet													1			٠-		•-			
ov. 16 Water Levels	feet	10:268	16.70	129.40	10:28a	DAY	DRY	10:35e	10.72	142.42	10:40	DAY	DRY	11:45a	DRY	DRY			• •	11:35e	6.41	53.30
ov. 22 Water Levels	feet	1:25p	16.36	129.74	· · ·	DRY	DRY		10.36	142.78	i	DRY	DRY	ĺ	DRY	DRY				1:10p	5.98	53.7
ec. 1 Water Levels	feet	9:57a	15.91	130.19	9:58a	16.85	129.79	10:05a	10.24	142.90	9:494	DRY	DRY	12:00p	DRY	DRY				10:14a	6.31	53.46
ec. 7 Water Levels	feet	1:40p	16.04	130.06	1:35p	16.98	129.66	1:45p	10.41	142.73	2:00p	DRY	DRY	12:10p	DRY	DRY		••	!	1:15p	6.61	53.16
ec. 15 Water Levels	feet	2:00p	16.22	129.68	1;55p	17.14	129.50	2:05p	10.58	142.56	2:30p	DRY	DRY	12:10p	DRY	DRY	٠-			1:40p	6.83	52.94
ec. 22 Water Levels	feet	1:55p	16.25	129.85	1:50p	17.24	129.40	2:00p	10.36	142.78	2:15p	DRY	DRY	12:10p	DRY	DRY	•••			2:50p	6.38	53.39
ec. 29 Water Levels	feet	1:45p	16.25	129.85	1:10p	17.24	129.40	1:55p	10.46	142.68	2:20p	DRY	DRY	12:40p	DRY	DRY				2:45p	6.38	53.39
an, 5 Water Levels	feet	7:33p	15.91	130,19	7:33p	16.80	129.64	7:33p	9,90	143.24	7:20p	DRY	DRY	i	DRY	DRY			••	7:50p	6.10	53.6
an. 5 flEXIDIP Probe oil det	cted	1	••		i	••		İ	••		ł	••		1	••		l	••		l		
en. 24 Mater Levels	feet	2:05p	15.81	130.29	2:00p	16.67	129.97	2:10p	10.12	143.02	2:30p	DRY	DRY	1 11:40a	DRY	DAY				1:50p	6.25	53.57

#### MOTES:

1. A Volctay/Bentonite seal was placed between the bottom of

the boring and the sand pack

2. BGS = Below Ground Surface

3. GS = Ground surface 4. TOC = Top of Casing

5. -- \* Indicates not available or applicable

6. ELE . Elevation Above City of Tacoma Datum

(MILW IS approximately 7,6 ft above the City of Tacoma Datum)

7. a = am, p = pm

8. DIW for 8:35 Nov. 10, intermediate tide and low tide based on transacer data

Table B-5.
Well and Water Level Data (Continued)

ASARCO - Remedial Investigation lable B 5 Well and Water Level Data

	 ۱۰۰۰، ۱۰۰۰، ۱۰۰۰، ۱									ASE      								PHASE II	
eli & Boring Data \ Wame	(units)			D-33			■-34			B-35			8-36			0-37	STAFF	GAGE AT 1	
ate Installed				85EPT88			155EP188	•••••	•••••	155EPT88			65EP188			165EP188		A DOCK	
otal Boring Depth	teet			44.5			29.5			47.0			29.5			22.0	ì		
op of Screen - BGS	feat			9.0			9.0			33.0			9.0			9.0	i		19Jan8
ttom of Screen - 8GS	feet			19.0			19.0			43.0			19.0	į		19.0	ĺ		
p of Screen Elevation	feet			17.2			17.9			-7.0			18.3	į		15.6	ĺ		
ttom of Screen Elevation	feet			7.2			7.9			·17.0			8.3			5.6	i		
Elevation	feet			26.20			26.93			26.00			27.3			24.59	1		
C Elevation	feet			27.46			28.93			27.66			28.9			26.33	1		26.6
ter Level Date			0.33	1		0-34	1		u - 35		• • • • • • • • • • • • • • • • • • • •	B-36		 	●-37		; [	TIDE GAGE	
ate	(units)	TIME		ELECTI)	TIME		ELE(FT)			ELE(FT)	TIME		ELE(FT)			ELE(F1)	TEME	DIW(FI)	ELECFT
t. 13 to Oct 20 Sampling	feet		16.36	11.10		16.25	12.68	3:49p	10.11	17.55	3:50p	12.44	16.49		9.55	16.78			• • • • • • •
t. 19 Lou Tide	feet		16.82	10.64	••	13.24	15.69		15.41	12.25		12.81	16.12	9:38e	9.63	16.70	9:10a	13.68	12.
t 19 Medium Tide	feet	••	13.68	13.78		14.10	14.83		12.52	15.14		12.74		••		• •	12:35p	7.81	18.
t. 19 High Tide	feet	•••	9.70	17.76		12.83	16.10	••	10.21	17.45	••	12.37	16.56	3:45p	9.61	16.72	4:55p	10.28	16.
t. 27 Water Levels	feet	1:49p	11.65	15.81	1:46p	13.17	15.76	1:57p	11.32	16.34	2:00p	12.09	16.84	2:32p	9.98	16.35	2:08p	7.94	18.
v. 2 Water Levels	feet	10:14e	14.25	13.21	9:46a	14.37	14.56	9:564	12.55	15.11	10:03a	12.37	16.56	9:20a	9.56	16.77	10:15e	6.47	20.
rv. 10 High Tide	feet	4:10p	10.63	16.83	4:06p	11.67	17.26	4:14p	9.54	18.12	4:20p	9.21	19.72	5:06p	7.61	18.72	4:05p	7.75	18.
v. 10 Intermediate Tide	feet	7:40p	10.53	16.93	7:57p	12.14	16.79		10,17	17.49	7:52p	10.55	18.38	6:25p	8.45	17.88	7:30p	13.25	13.
v, 10 Lou lide	feet	11:16p	14.88	12.58	11:25p	15.92	13.01		13.42	14.24	11:33p	10.67	18.06	11:45p	7.25	19.08	11:21p	20.70	5.
v. 16 Water Levels	feet				12:31a	.12,11	16.82	12:45p	9.09	18.57	12:40p	11.73	17.20	12:10p	7.86	18.47	12:49p	7.43	19.
w. 22 Water Levels	feet		10.18	17.28	••	12.16	16.75		10.36	17.30	••	10.85	18.08		7.38	18.95	9:00a	10.40	16.
c. 1 Weter Levels	feet	11:23a	9.93	17,53	11:28e	12.82	16,11	11:42a	10.00	17.66	11:51a	12.05	16.88	10:53a	7.96	16.37	11:194	6.70	19.
c, 7 Water Levels	feet	8:420	10.13	17.33	8:35a	12.91	16.02	8:57e	10.50	17.16	8:49a	13.58	15.35	9:53a	8.72	17.61	8:30a	9.81	16.
c. 15 Water Levels	feet	9:55a	11.23	16.23	10:15a	13.46	15.47	11:50a	10.49	17.17	11:25a	12.58	16.35	10:45a	9.22	17.11	9:50a	6.93	19.
c. 22 Water Levels	feet	9:20a	9.12	18.34	10:00a	11.57	17.36	9:50a	9.37	18.29	9:40a	10.41	16.52	11:00a	9.11	17,22	9:160	9.21	17.
c. 29 Water Levels	feet	9:30a	10.52	16.94	9:40a	13.13	15.80	9:45a	10.70	16.96	10:05a	12.41	16.52	11:30a	8.70	17.63	9:254	6.63	19.
n, 5 Hater Levels	feet	8:43p	15.53	11.93	9:00p	16.20	12.73	9:05p	14.88	12.78	8:48p	11.65	17.28	9:52p	8.24	18.09	10:03p	20.48	6.
ın, 5 FLEXIDIP Probe ail det	ected	Ì	- 140	i		- #0	į		- NO	i		-#0		i '	- NO		i	••	
n, 24 Water Levels	feet	9:05.	9.49	17.97	9:45	12,77	16.16	9:40a	10.08	17.58	9:25a	12.16	16.77	10:45a	8.38	17.95	9:00	8.26	18.

#### HOIES:

 A Voicisy/Bentonite seat was pieced between the bottom of the boring and the sand pack

2. BGS \* Below Ground Surface

3. GS • Ground surface

4. TOC = Top of Casing

5, -- a Indicates not available or applicable

6. ELE . Elevation Above City of Tecome Datum

(MLEW is approximately 7.6 ft above the City of Tacoma Datum)

7. a = am, p = pm

8. DTW for 8-35 Nov. 10, Intermediate tide and low tide based on translucer data

Table B-5. Well and Water Level Data (Continued)

### Key to Exploration Logs Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual—manual classification methods of ASTM 0 2488 were used as an identification guide.

Soil descriptions consist of the following: Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

### Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	N, Penetration Resistance in Blows/Foot	SILT or CLAY Consistency	N, Penetretion Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very lagse	0 - 4	Very soft	o - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		' Hard	>30	. >2.0

Mois	ture
□ry	Little perceptible moisture
Camp	Same perceptible maisture. probably below optimum
Moist	Probably near optimum moisture contant
Wet	Much perceptible moisture. probably above optimum

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

### Legends

### Sampling BORING SAMPLES

Split Spoon

Shelby Tube
Cuttings

\* No Sample Recovery

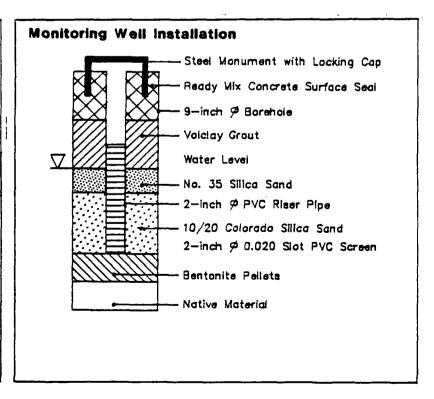
P Tube Pushed. Not Oriven

### Test Symbols

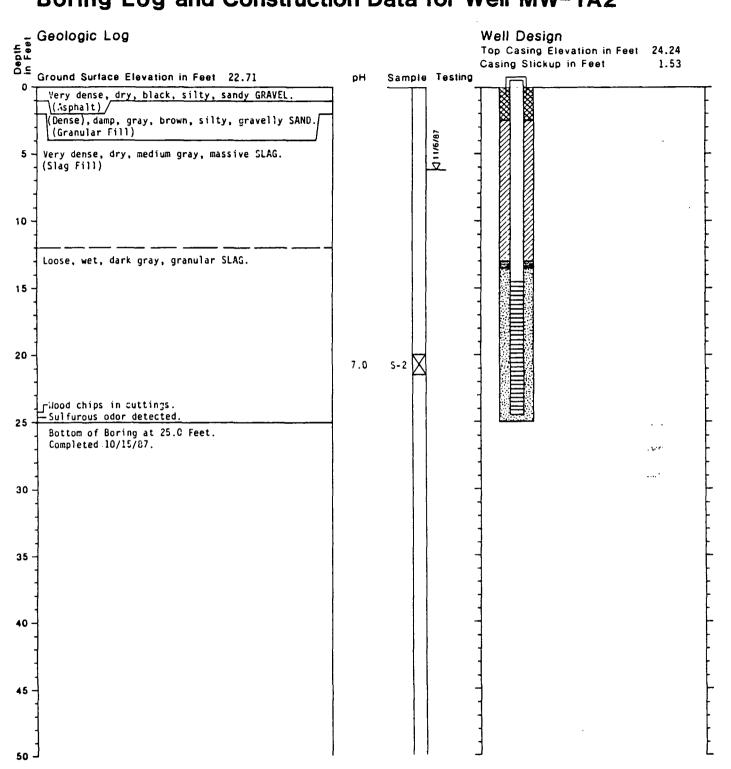
PCB

GS Grain Size Analysis MA Mechanical Grain Size HYD Hydrometer Grain Size ĸ Permeability CA Chemical Analysis MET Metal Analysis TPH Petroleum Hydrocarbon Analysis BTEX Benzene, Toulene, Ethylene, Xylene ABN Extractable

Polychloronated Biphenel Analysis



J-1824-32 February 1989 HART-CROWSER & associates.inc. Figure B-1.



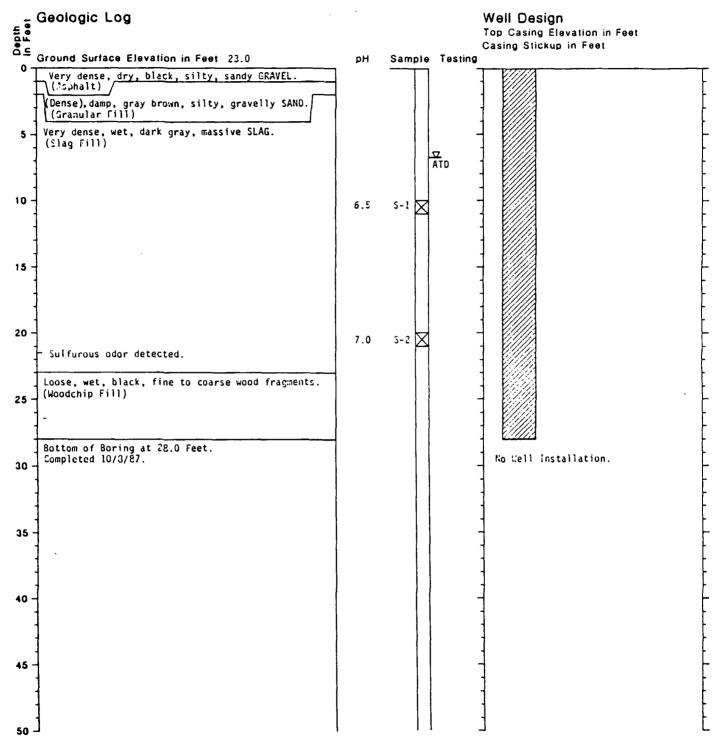
#### NOTES

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

J-1824-32 October 1987 HART-CROWSER & associates, inc.

Figure B-2.

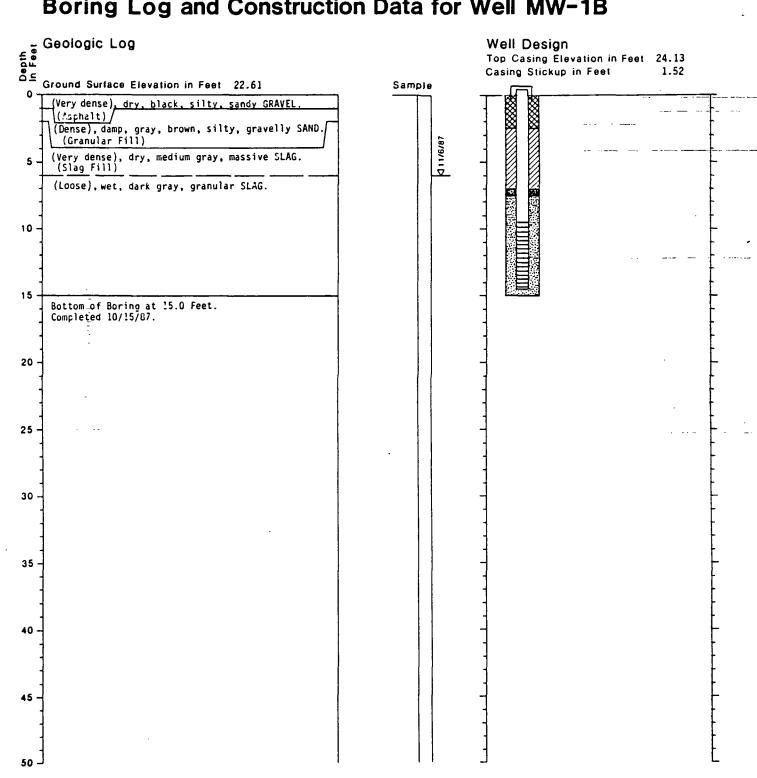
# Boring Log B-1A



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year, ATD:At Time of Drilling

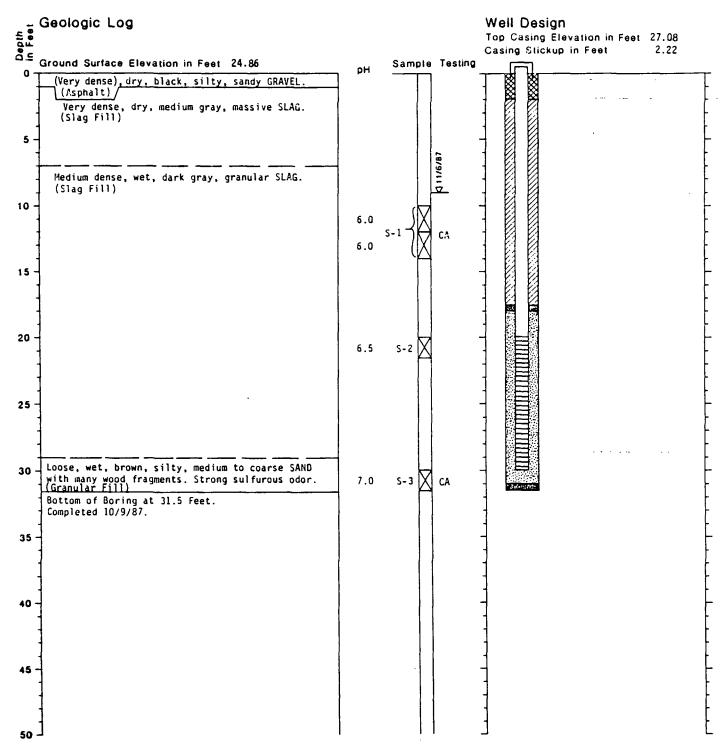
J-1824-32 September 1987 HART-CROWSER & associates, inc. Figure B-3.



#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

1987 J-1824-32 October HART-CROWSER & associates, inc. Figure B-4.

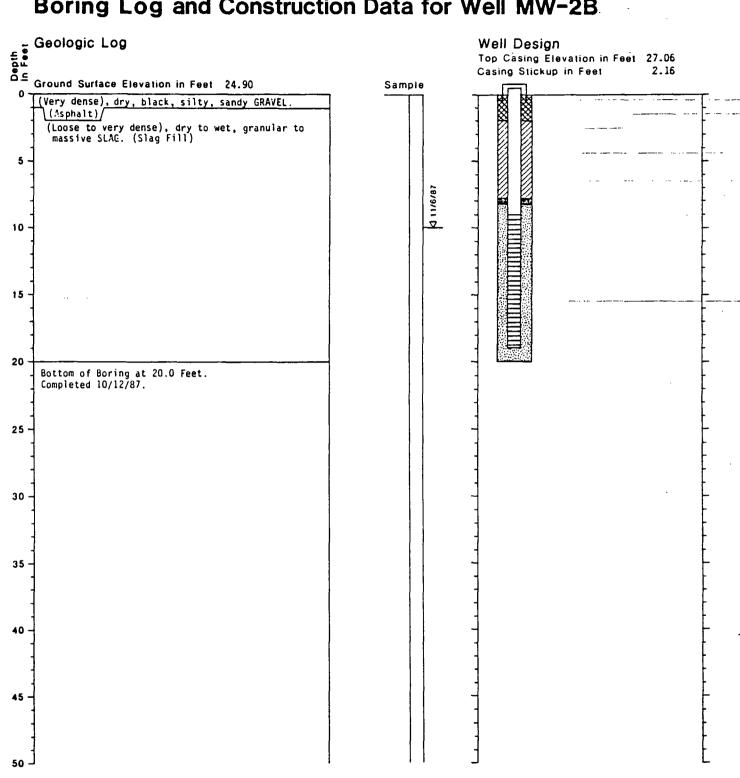


#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

J-1824-32 October 1987 HART-CROWSER & associates, inc.

Figure B-5.

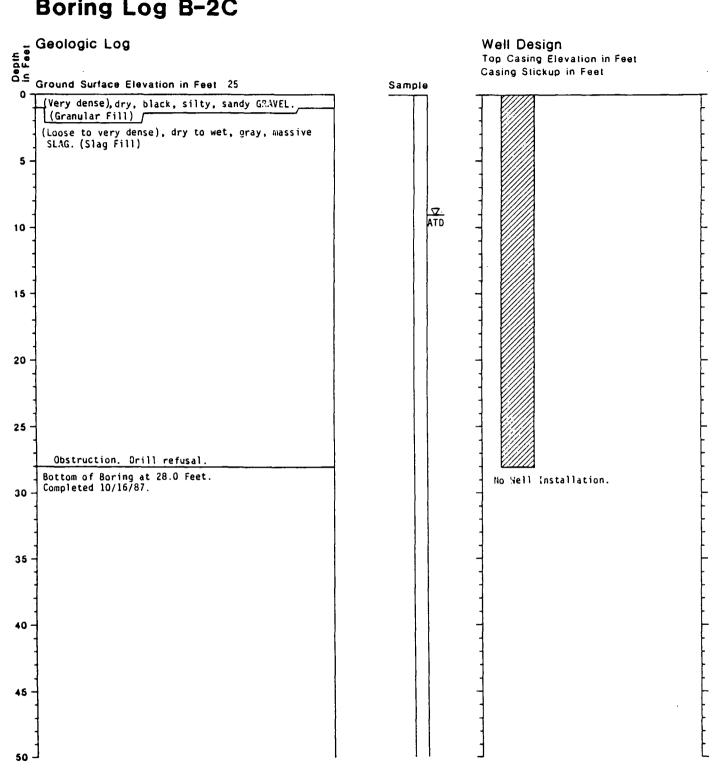


- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drifting

1987 J-1824-32 October HART-CROWSER & associates, inc.

Figure B-6.

### Boring Log B-2C

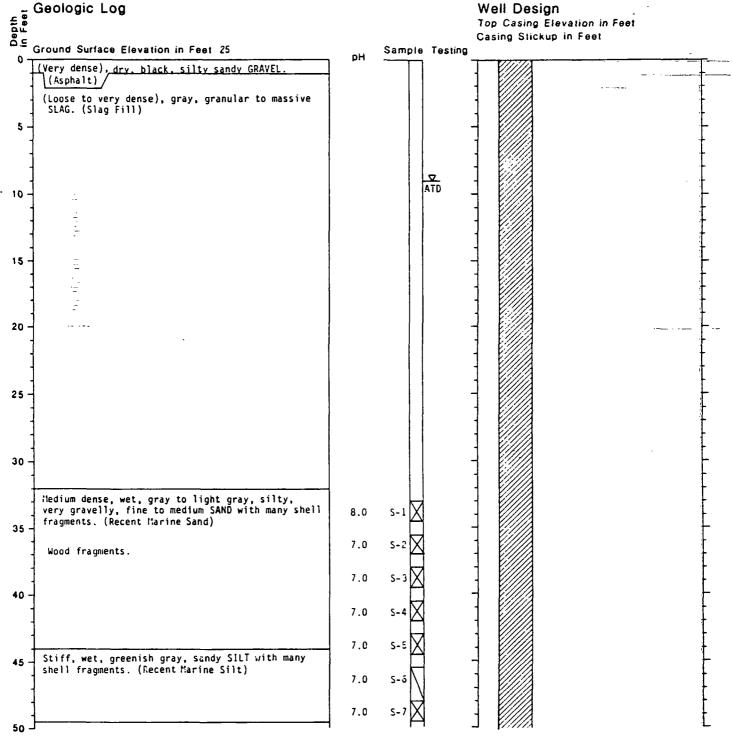


#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

J-1824-32 September 1987 HART-CROWSER & associates, inc.

### Boring Log B-2C2

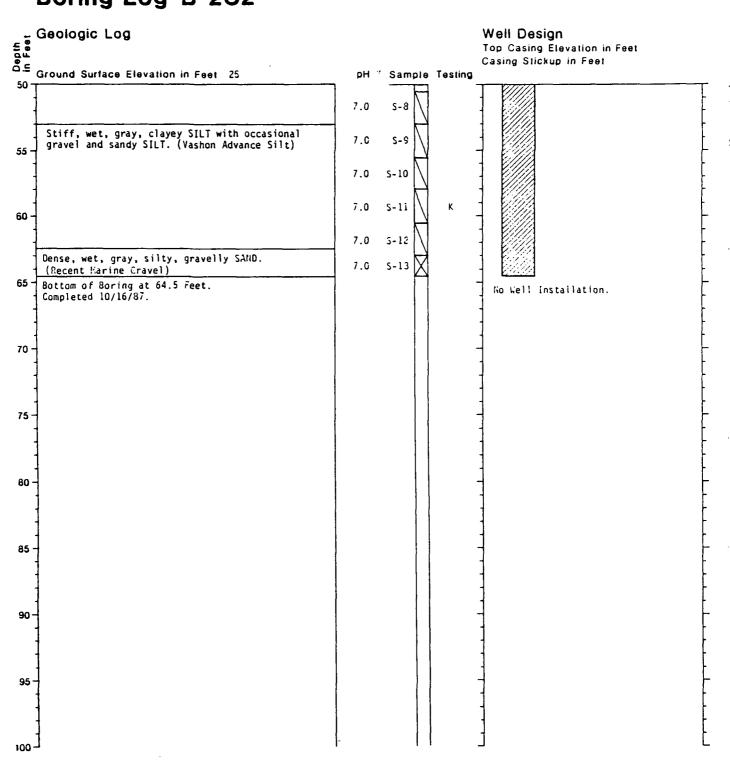


#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

J-1824-32 September 1987 HART-CROWSER & associates, inc. Sheet 1 of 2 Figure B-8.

### Boring Log B-2C2

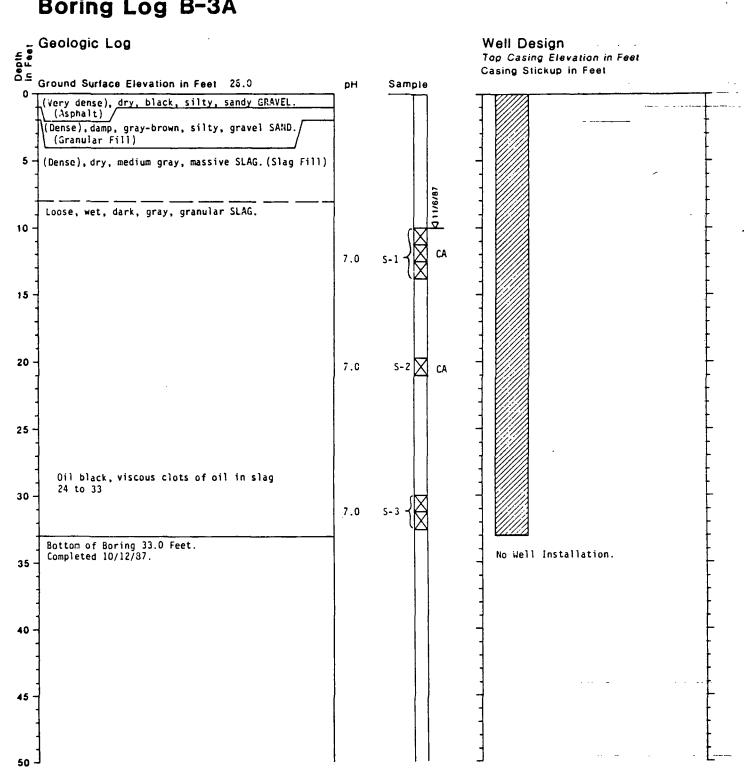


#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year, ATD:At Time of Drilling

J-1824-32 October 1987 HART-CROWSER & associates, inc. Sheet 2 of 2 **Figure B-8.** 

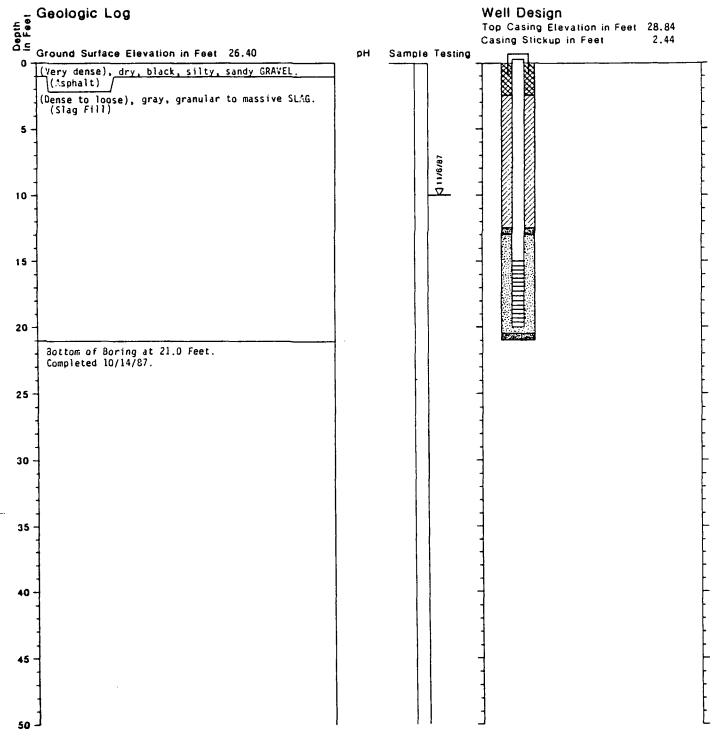
### Boring Log B-3A



#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- 2. Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

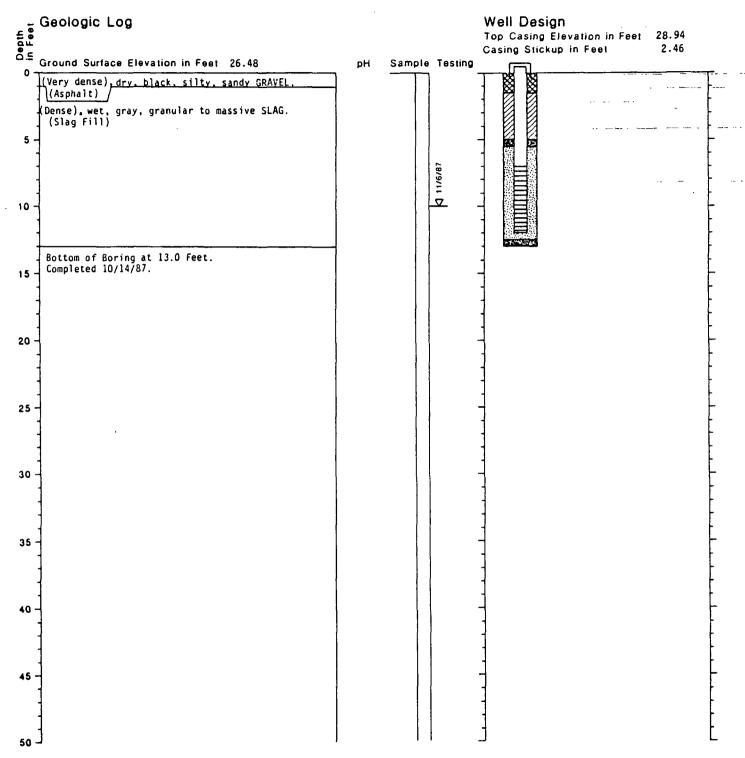
1987 J-1824-32 September HART-CROWSER & associates, inc. Figure B-9.



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year, ATD:At Time of Drilling

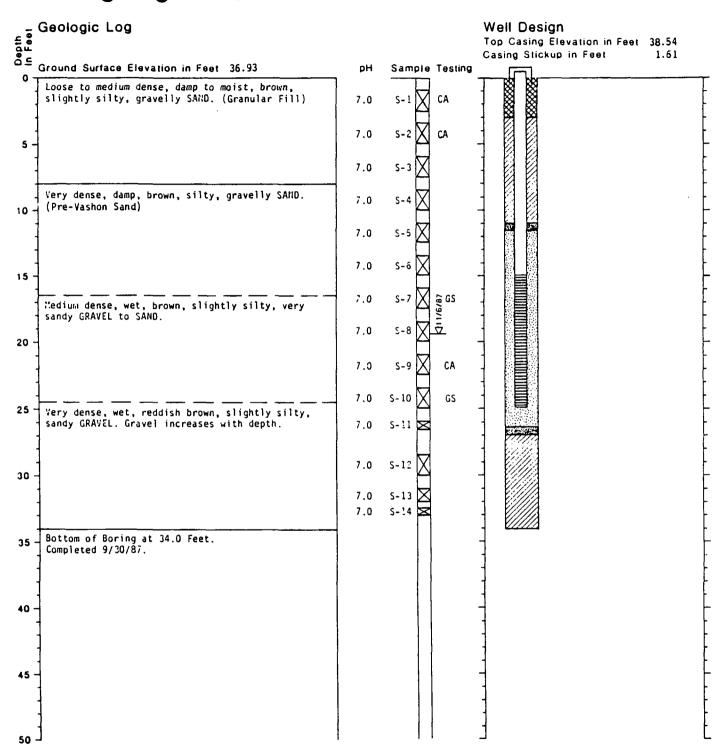
J-1824-32 October 1987 HART-CROWSER & associates, inc.



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year, ATD:A1 Time of Drilling

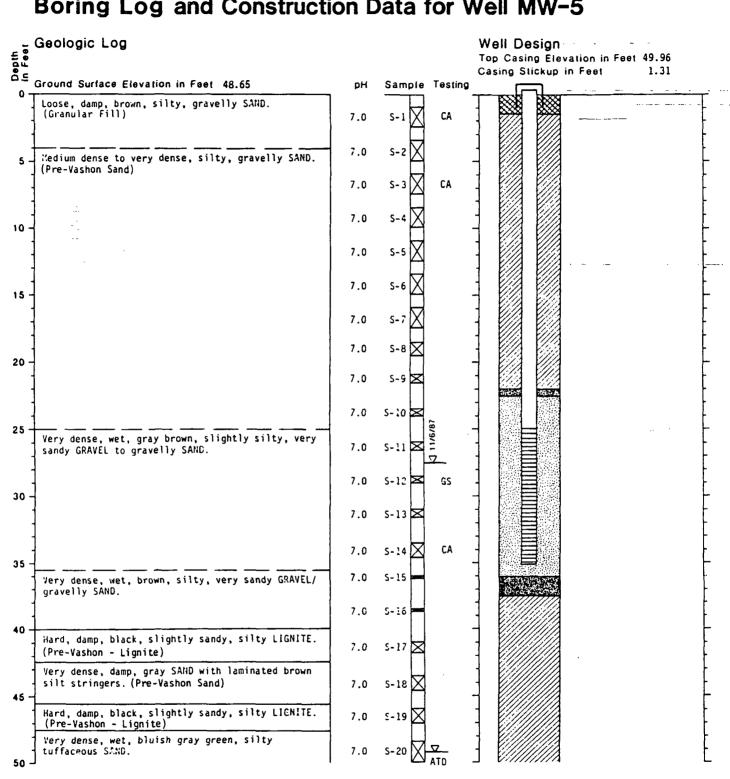
J-1824-32 October 1987 HART-CROWSER & associates, inc.



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Orifling

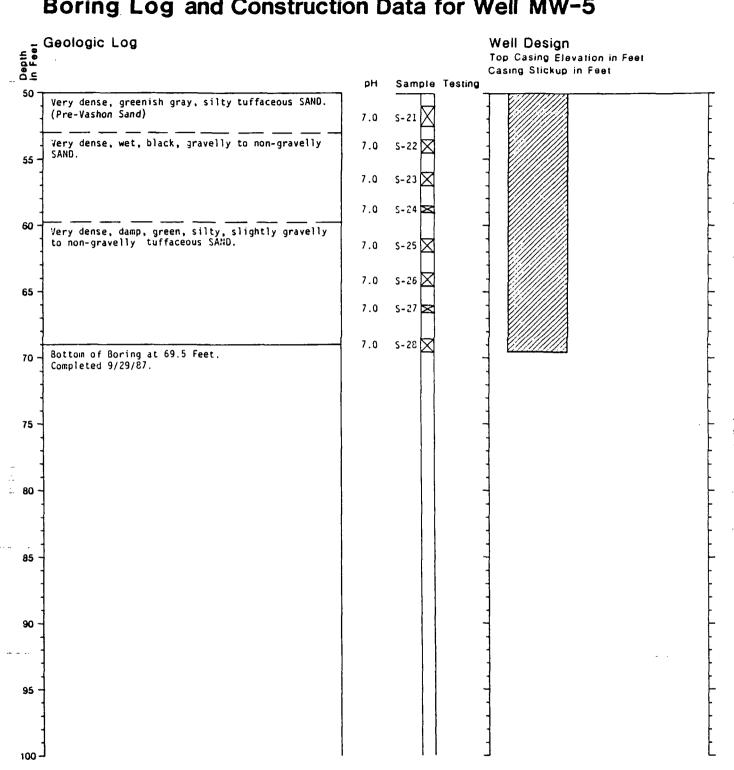
J-1824-32 October 1987 HART-CROWSER & associates, inc. Figure B-12.



#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may very with time of year, ATD:At Time of Drilling

J-1824-32 October 1987 HART-CROWSER & associates, inc. Sheet 1 of 2 Figure B-13.

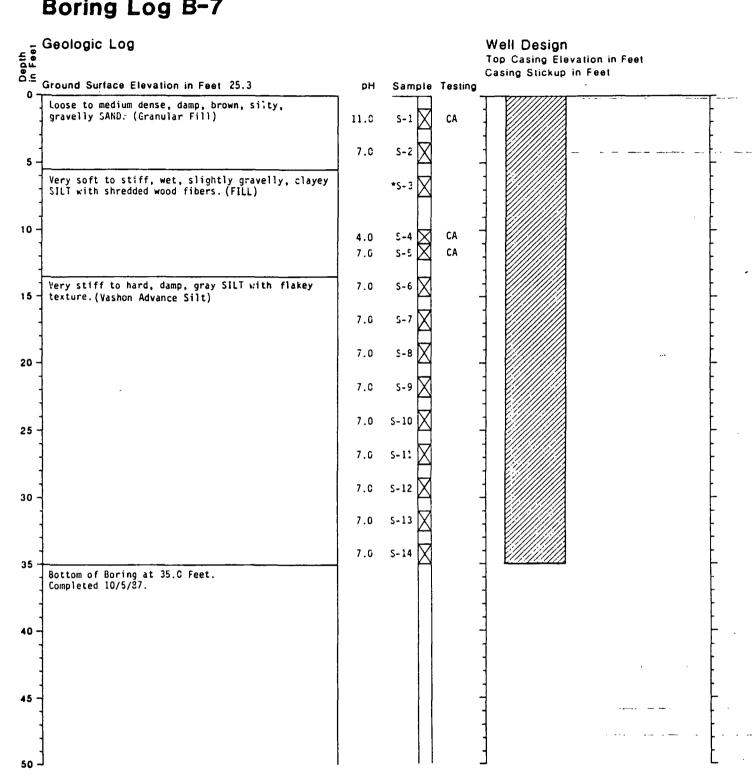


#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATO:At Time of Drilling

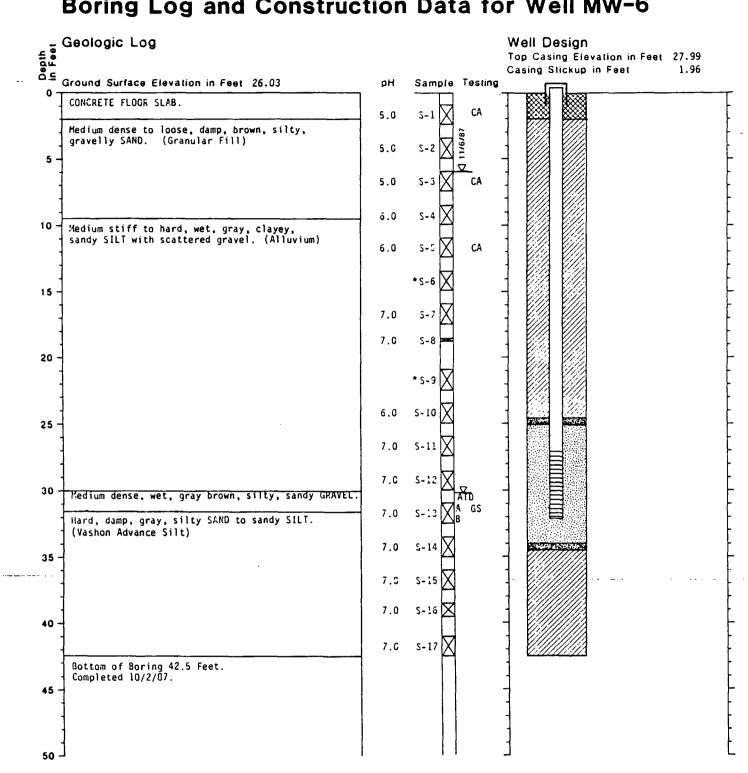
J-1824-32 October : 1987 HART-CROWSER & associates, inc. Sheet 2 of 2 Figure B-13.

### Boring Log B-7



- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

1987 J-1824-32 October HART-CROWSER & associates, inc. Figure B-14.

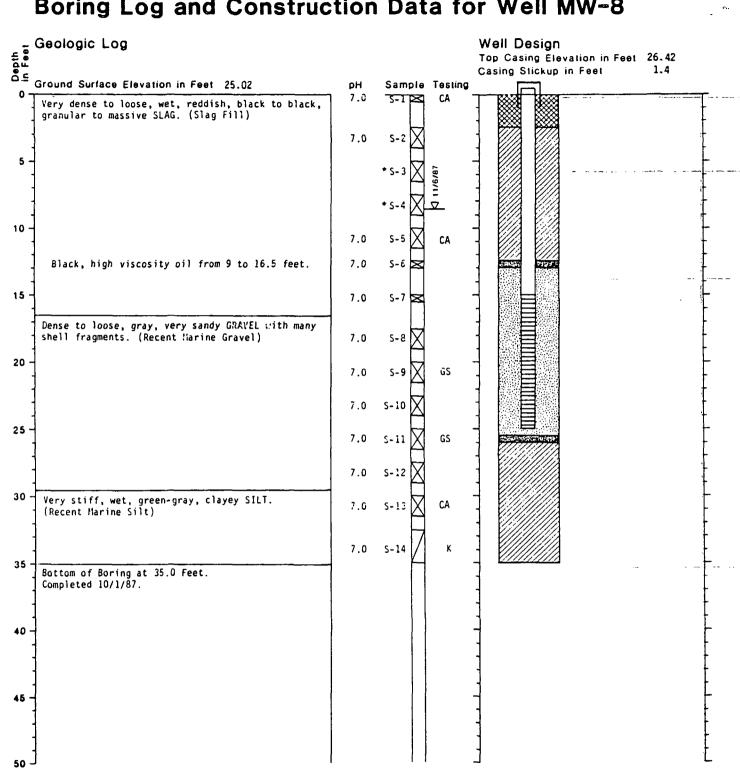


#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

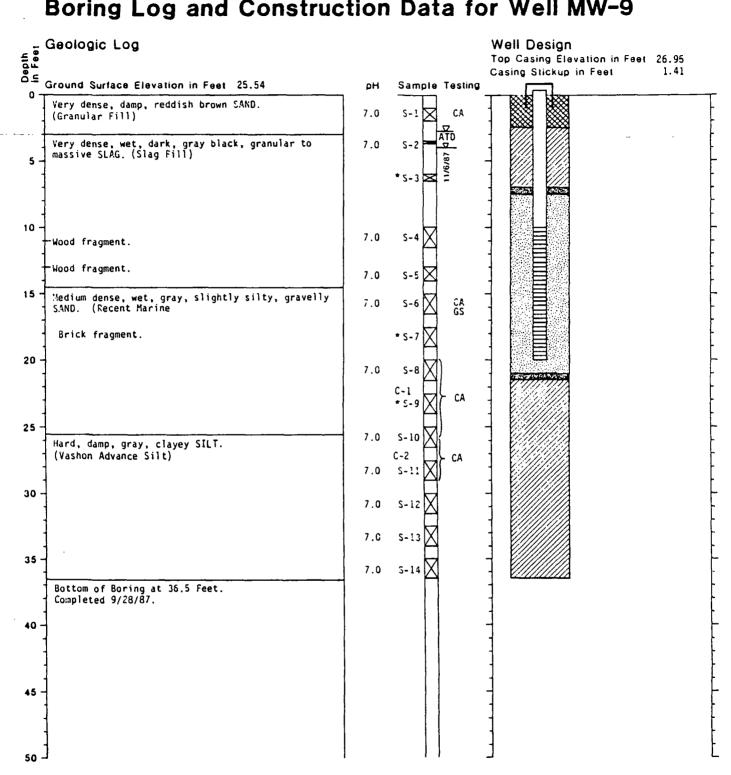
J-1824-32 October 1987 HART-CROWSER & associates, inc.

Figure B-15.



- 1. Soil descriptions are interpretive and actual changes may be gradual.
- 2. Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

1987 J-1824-32 October HART-CROWSER & associates, inc. Figure B-16.



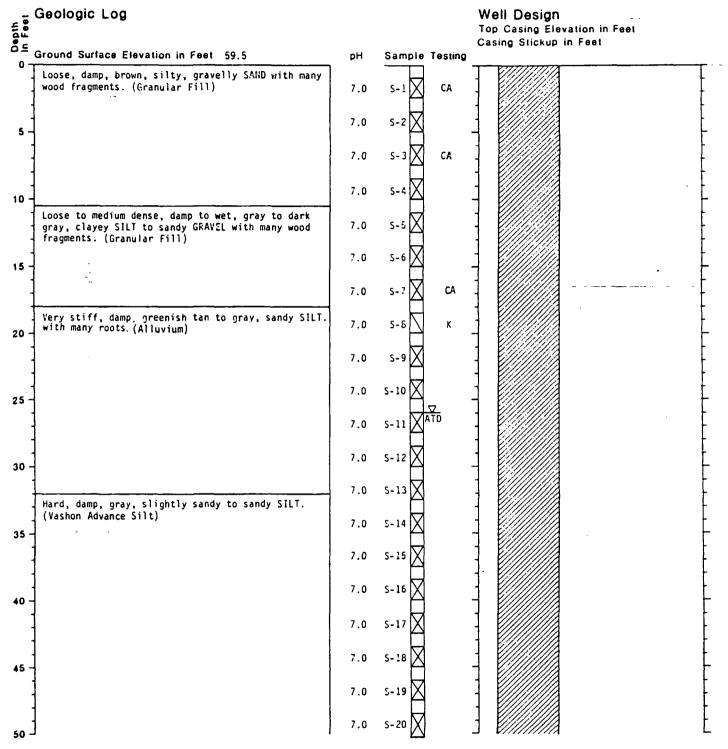
#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- 2. Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

Figure B-17.

1987 J-1824-32 October HART-CROWSER & associates, inc.

### Boring Log B-10

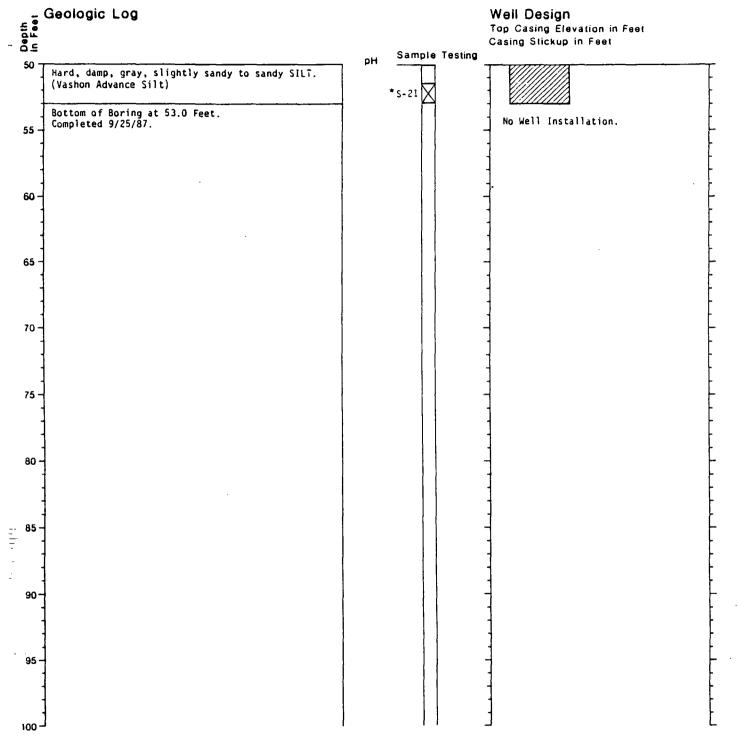


#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

J-1824-32 September 1987 HART-CROWSER & associates, inc. Sheet 1 of 2 Figure B-18.

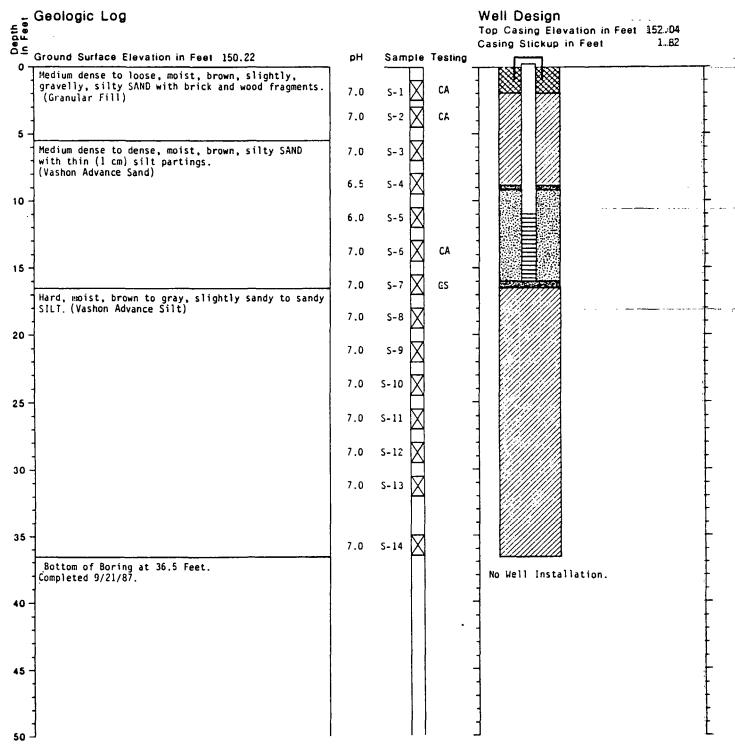
### Boring Log B-10



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

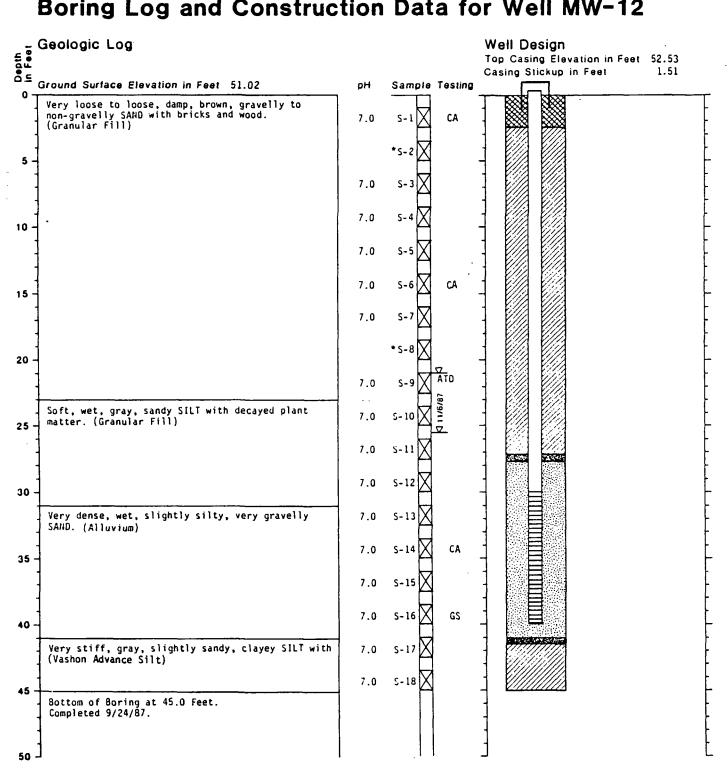
J-1824-32 September 1987 HART-CROWSER & associates, inc. Sheet 2 of 2 Figure B-18.



#### MOTES.

- Soil descriptions are interpretive and actual changes may be gradual.
- 2. Water Level is for date indicated and may vary with time of year, ATD:At Time of Drilling

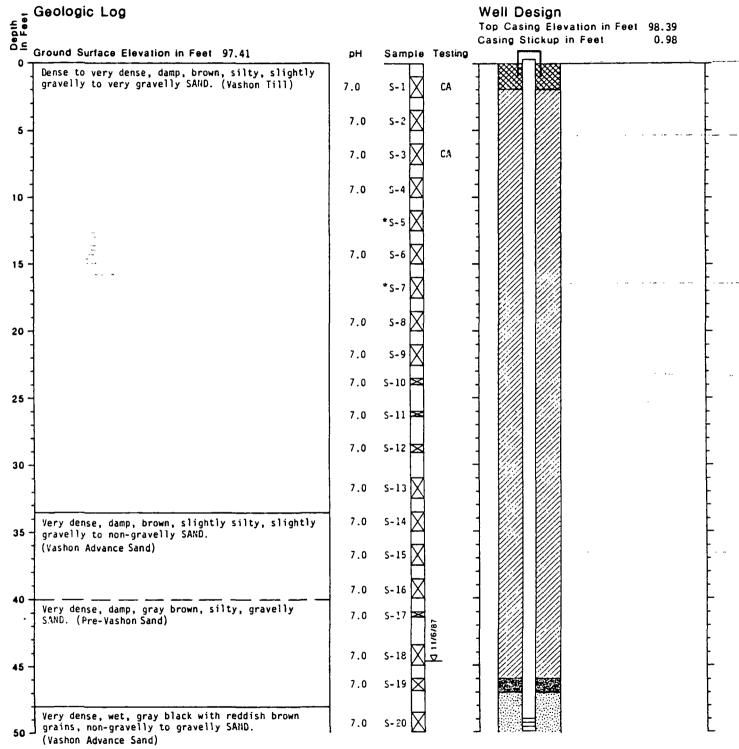
J-1824-32 October 1987 HART-CROWSER & associates, inc. Figure B-19.



#### NOTES:

- 1. Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Driffing

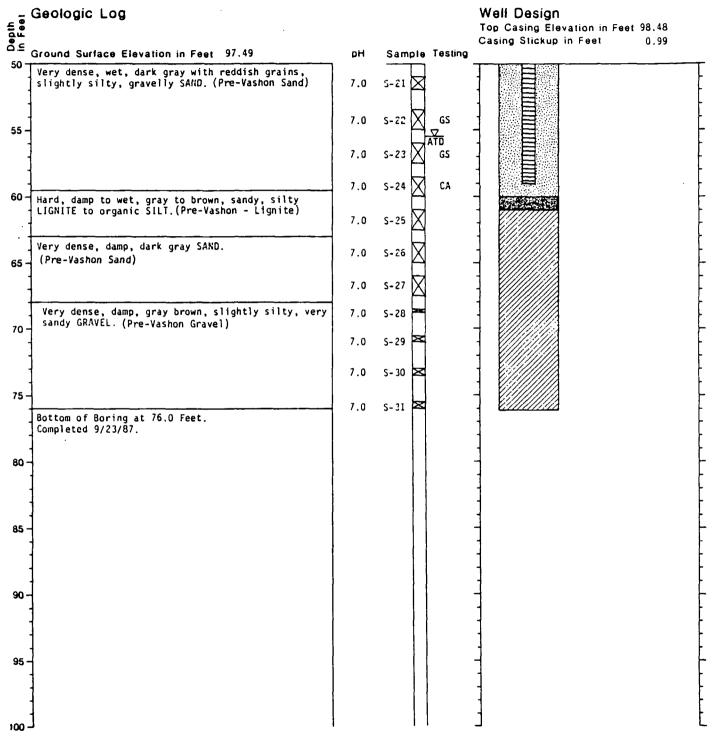
1987 J-1824-32 September HART-CROWSER & associates, inc. Figure B-20.



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- Water Level is for date indicated and may vary with time of year. ATD:At Time of Dritting

J-1824-32 September 1987 HART-CROWSER & associates, inc. Sheet 1 of 2 **Figure B-21.** 



#### NOTES:

- Soil descriptions are interpretive and actual changes may be gradual.
- 2. Water Level is for date indicated and may vary with time of year. ATD:At Time of Orilling

J-1824-32 September 1987 HART-CROWSER & associates, inc. Sheet 2 of 2 Figure B-21.

# Boring Log and Construction Data for Monitoring Well B-14

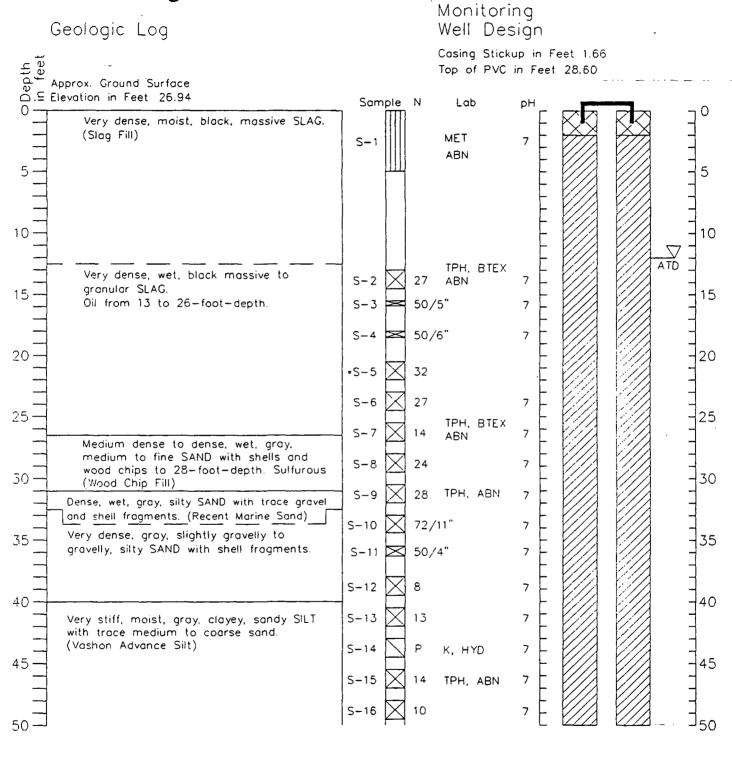


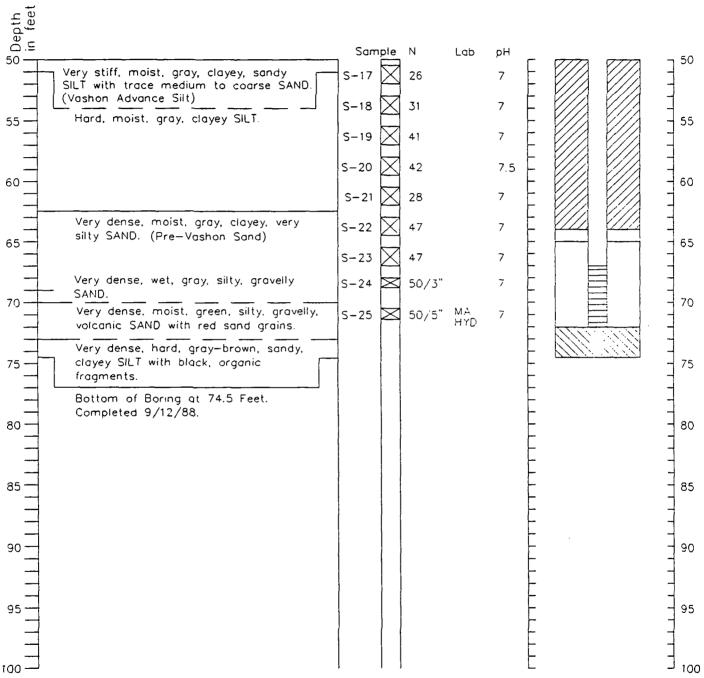


Figure B-22.

1/2

# Boring Log and Construction Data for Monitoring Well B-14

Geologic Log Monitoring
Well Design



- Refer to Figure 8-1 for explanation of descriptions and symbols.
- Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
- 4. Odex drilling to 10 feet.
- 5. 3 inch split spoon sampler with 300 lb. hammer.



J-1824-32

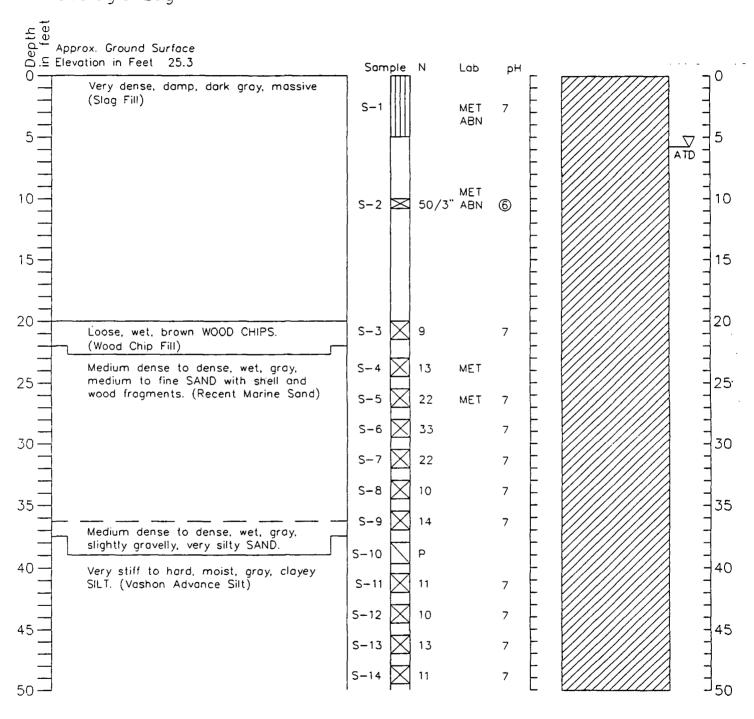
9/88

Figure B-22.

2/2

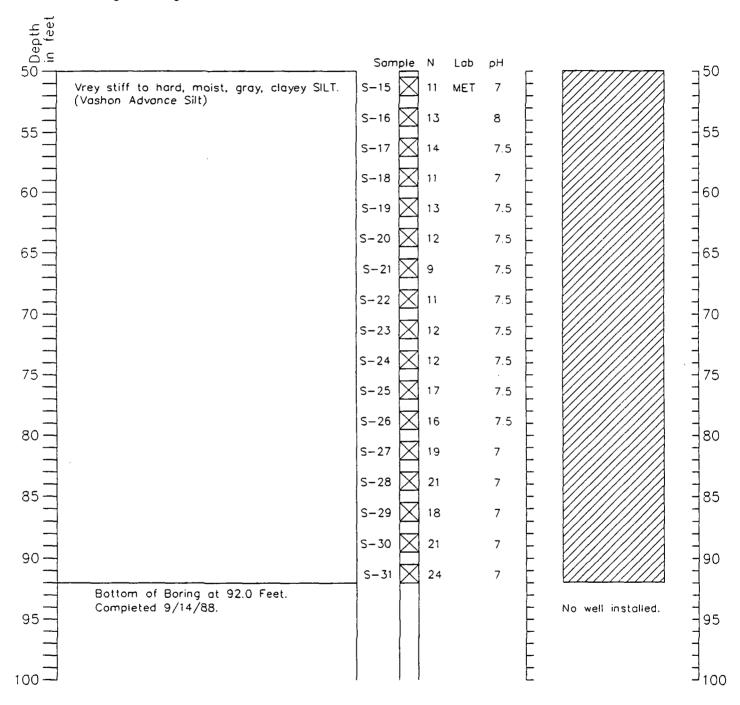
### Boring Log B-15

Geologic Log



# Boring Log B-15

Geologic Log



- Refer to Figure 8-1 for explanation of descriptions and symbols.
- 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
- 4. Odex drilling to 10 feet.
- 5. 3 inch split spoon sampler with 300 lb. hammer.



J-1824-32

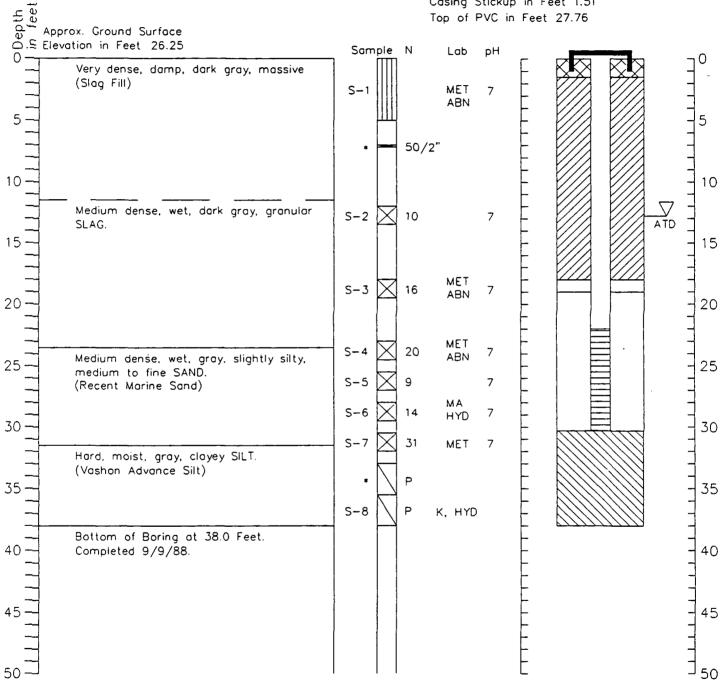
9/88

Figure B-23. 2/2

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.51



- 1. Refer to Figure B-1 for explanation of descriptions and symbols.
- 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- 3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
- 4. Odex drilling to 7 feet.
- 5. 3 inch split spoon with 140 lb. hammer.



J-1824-32

9/88

Figure B-24.

Geologic Log Well Design Approx. Ground Surface

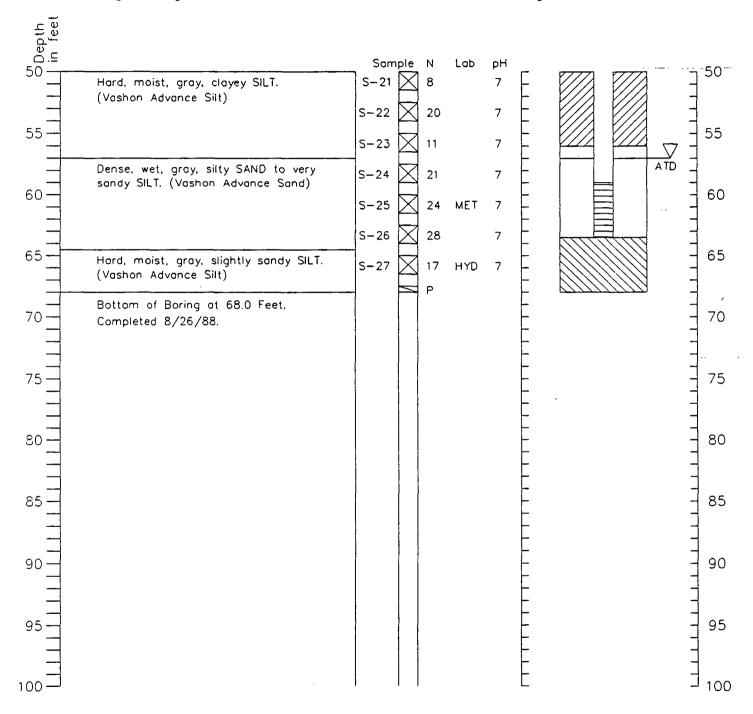
O.5 Elevation in Feet 151.81 Casing Stickup in Feet 1.62 Top of PVC in Feet 153.43 Sample N Lab рΗ 0 S-1 ∭ Medium dense, damp, brown, slightly silty, sandy GRAVEL. (Granular Fill) MET S-2 17 7 ABN Medium dense, damp, gray-brown, silty to very silty, fine SAND. MAS-3 20 6 (Vashon Advance Sand) HYD S-424 6 MET 10 10 7 S-5 6 Very stiff to hard, moist, gray, clayey SILŤ. (Vashon Advance Silt) S-6 13 7 15 15 S-712 HYD 7 S-8 11 7 20 20 S-9 14 S-10 14 25 25 S-11 13 S-12 13 Slightly sandy SILT. 30 30 S-13 22 S-14 16 7 35 35 S-15 7 HYD S-16 MET 7 40 40 S-17 7 S-18 11 45 S-19 12 7 S - 20₫<sub>50</sub>

Figure B-25.

1/2

Geologic Log

Monitoring Well Design



Refer to Figure B-1 for explanation of descriptions and symbols.

4. 2 inch split spoon sampler with 300 lb. hammer.



J-1824-32

8/88

Figure B-25.

2/2

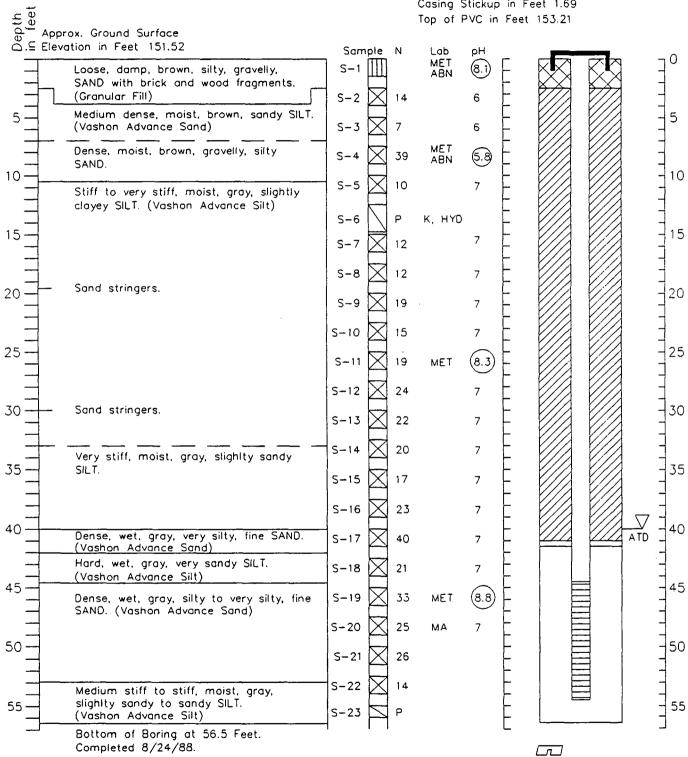
<sup>2.</sup> Soil déscriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.69 Top of PVC in Feet 153.21



1. Refer to Figure B-1 for explanation of descriptions and symbols.

2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

4. Soil samples taken with SPT to 40 feet. 2 inch split spoon sampler with 300 lb. hammer from 40 to 56.5 feet.

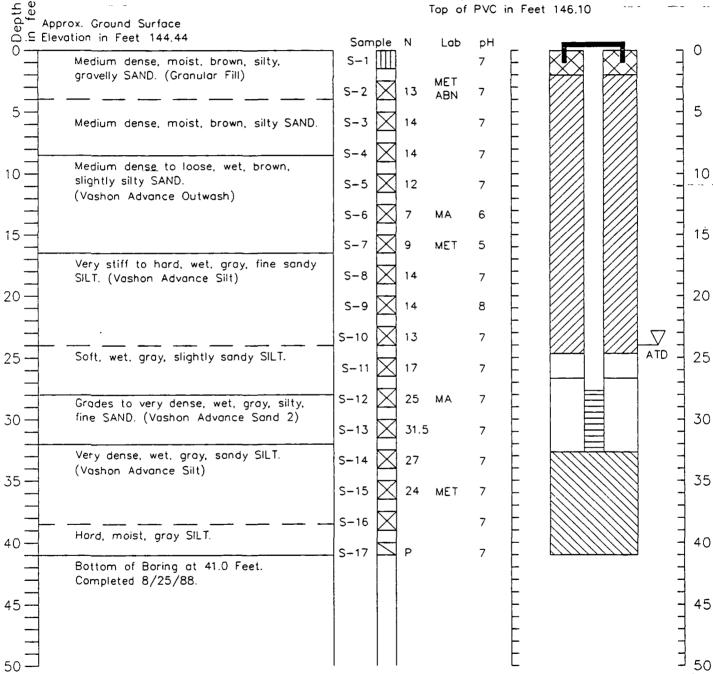


Figure B-26.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.66
Top of PVC in Feet 146.10



Refer to Figure B-1 for explanation of descriptions and symbols.

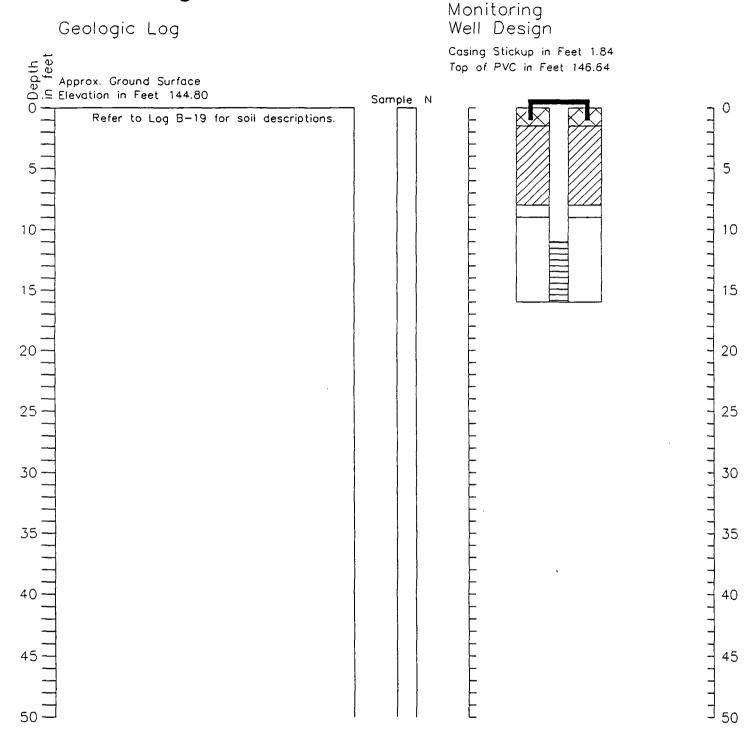
4. 2 inch split spoon samples with 300 lb. hammer.



Figure B-27.

Soil déscriptions and stratum lines are interpretive and actual changes may be gradual.

Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.



Refer to Figure B-1 for explanation of descriptions and symbols.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.



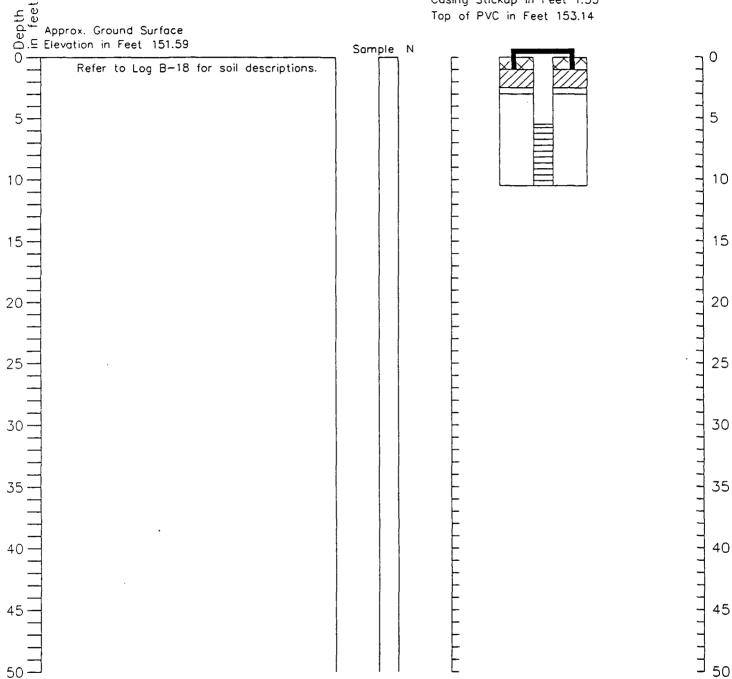
Figure B-28.

Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.55



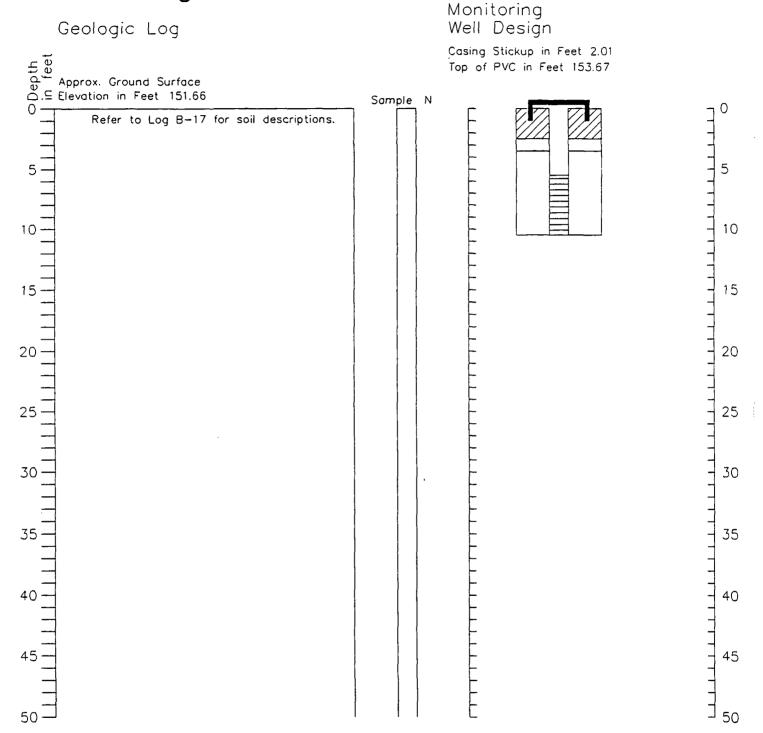
<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.

2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.



Figure B-29.



Refer to Figure B-1 for explanation of descriptions and symbols.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

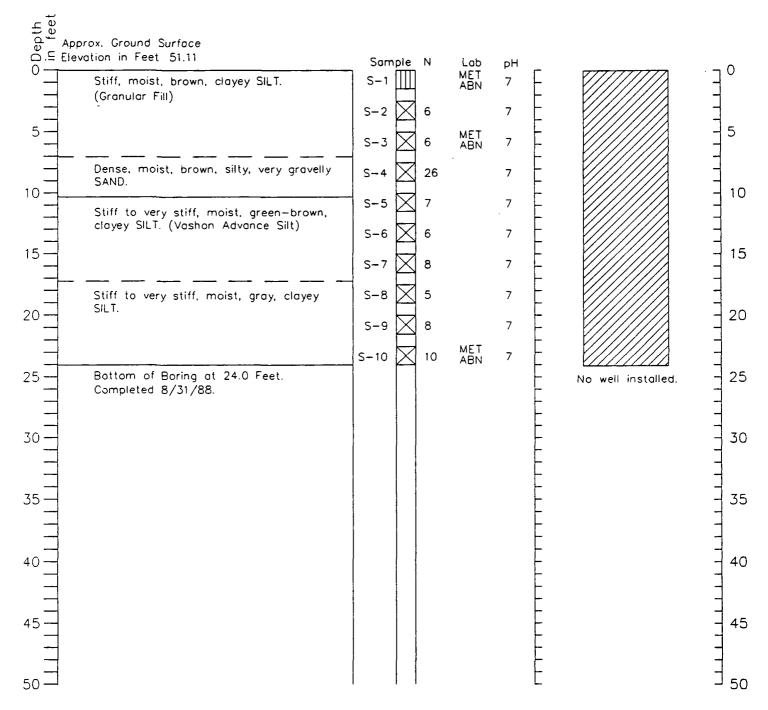


Figure B-30.

Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

#### Boring Log B-23

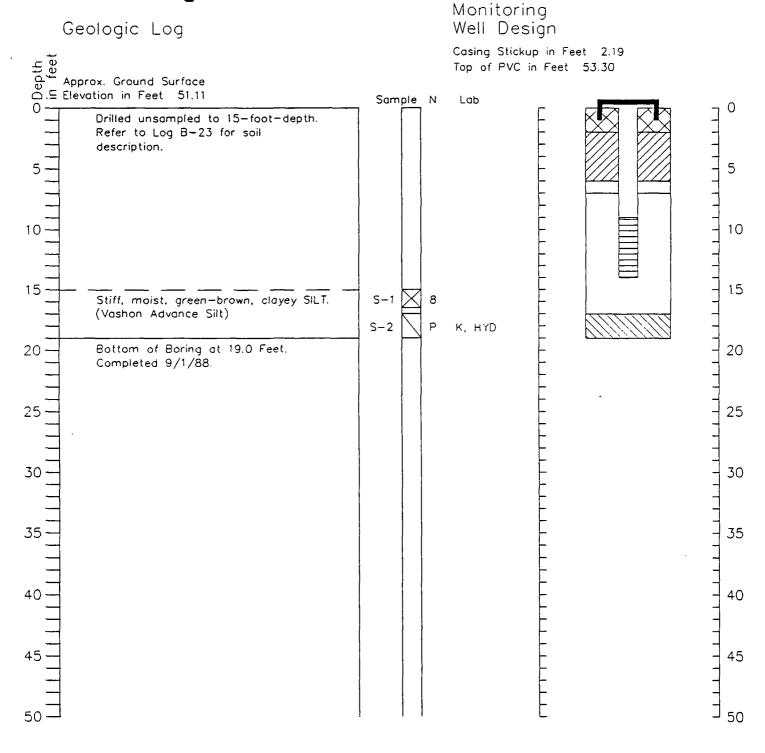
Geologic Log



- Refer to Figure 8-1 for explanation of descriptions and symbols.
- Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- 3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
- 4. 2 inch split spoon sampler with 300 lb. hammer.



Figure B-31.



Refer to Figure B-1 for explanation of descriptions and symbols.

4. 2 inch split spoon sampler with 300 lb. hammer.



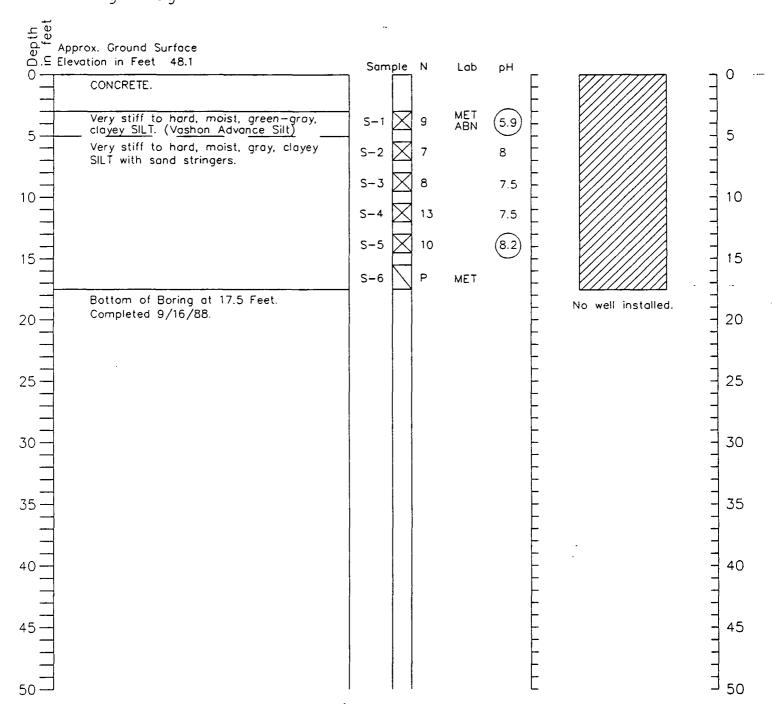
Figure B-32.

<sup>2.</sup> Soil déscriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

#### Boring Log B-24

Geologic Log



- Refer to Figure B-1 for explanation of descriptions and symbols.
- Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- 3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
- 4. 2 inch split spoon with 300 lb. hammer.



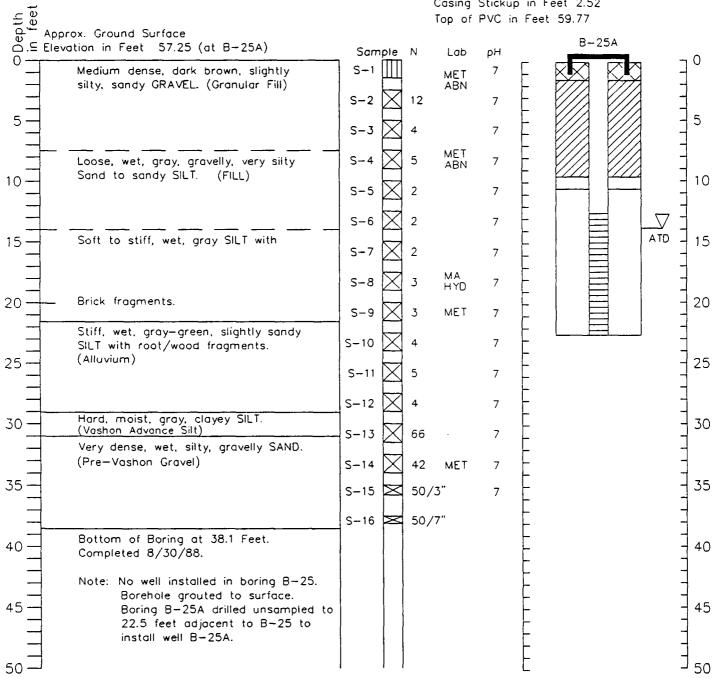
Figure B-33.

#### Boring Log for B-25 and Construction Data for Monitoring Well B-25A

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 2.52 Top of PVC in Feet 59.77



<sup>1.</sup> Refer to Figure B+1 for explanation of descriptions and symbols.

4. 2 inch split spoon sampler with 300 lb. hammer.



Figure B-34.

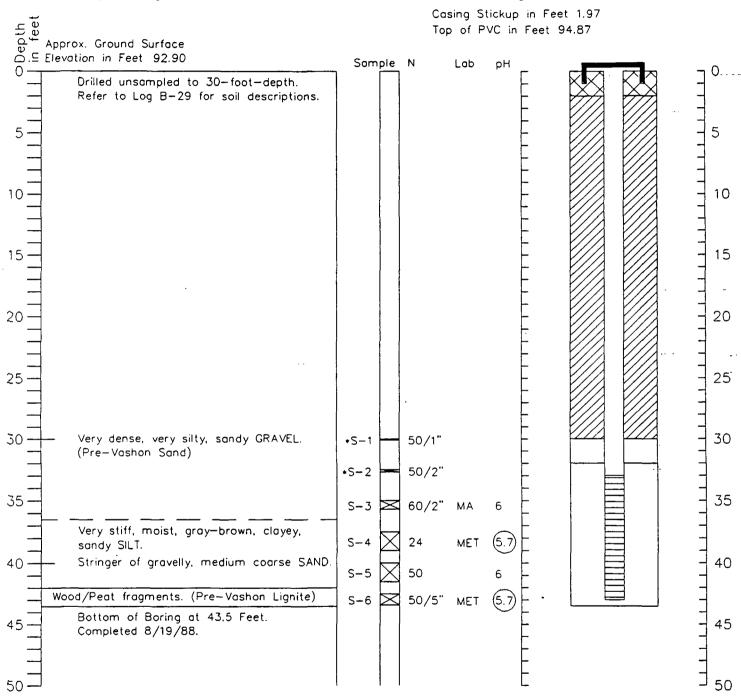
<sup>2.</sup> Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.97 Top of PVC in Feet 94.87



<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.

2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.



Figure B-35.

Well Design

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J-1824-32

Figure B-36.

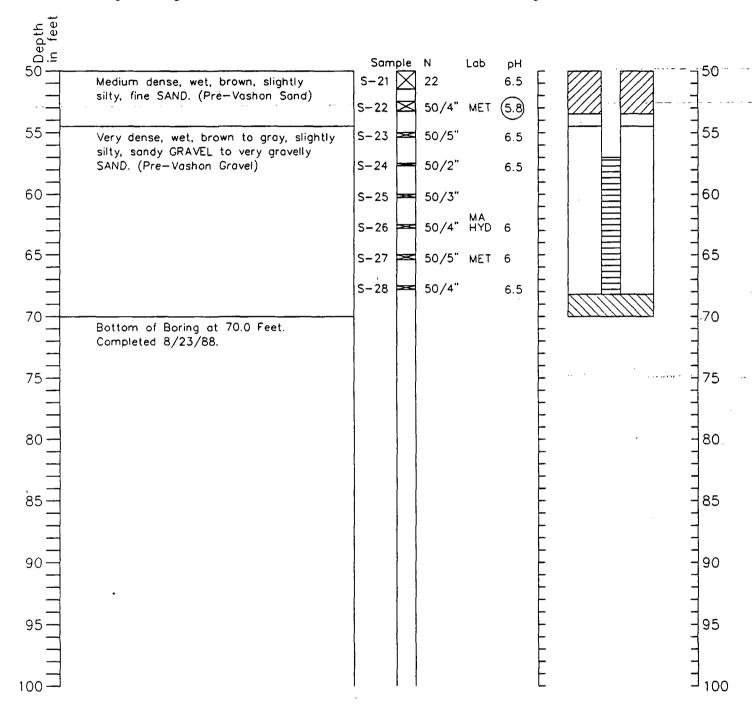
Geologic Log

Approx. Ground Surface

O.S. Elevation in Feet 77.22 Casing Stickup in Feet 1.28 Top of PVC in Feet 78.50 Sample N Lab (5.7) S-1 ∭ Medium dense, moist, slightly gravelly, MET silty SAND. (Granular Fill) ABN S-2 13 5 Dense, moist, gray to brown, silty, S-339 gravelly SAND. (Vashon Till) MET ABN (5.9 S-433 1 foot lens of green-brown, slightly 10 S-5 24 6.5 sandy SILT. S-6 52 6.5 15 S-791 6.5 S-8 57 6.5 20 20 S-9 46 6.5 S-10 50/4" 6 Very dense, brown, slightly silty, 25 25 MA HYD S-11 62 6 medium to fine SAND. (Vashon Advance Sand) MET S-12 54 (6.6) 30 30 S-13 40 6.5 S-14 80 6 35 Very dense, gray brown, gravelly, silty 35 50/3" S-15 🔀 6.5 SAND. (Pre-Vashon Sand) S-16 100/5" 6.5 40 S-17 100/5" 6.5 Very dense, moist, brown, silty, sandy GRAVEL. S-18 100/4" 6.5 45 No sample recovery. 45 \*S-19 100/2" 50/4" S-20 6.5 J<sub>50</sub> 50 -Medium dense, wet, brown, slightty silty, fine SAND.

Geologic Log

Monitoring Well Design



- Refer to Figure B-1 for explanation of descriptions and symbols.
- Soil déscriptions and stratum lines are interpretive and actual changes may be gradual.
- 3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.4. 2 inch split spoon sampler with 300 lb. hammer.

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J-1824-32

8/88

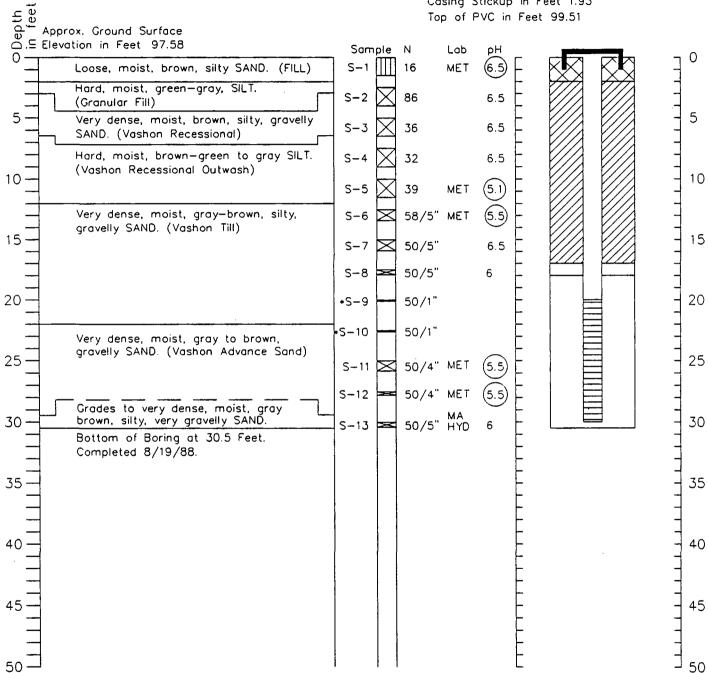
Figure B-36.

2/2

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.93 Top of PVC in Feet 99.51



1. Refer to Figure 8-1 for explanation of descriptions and symbols.

2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

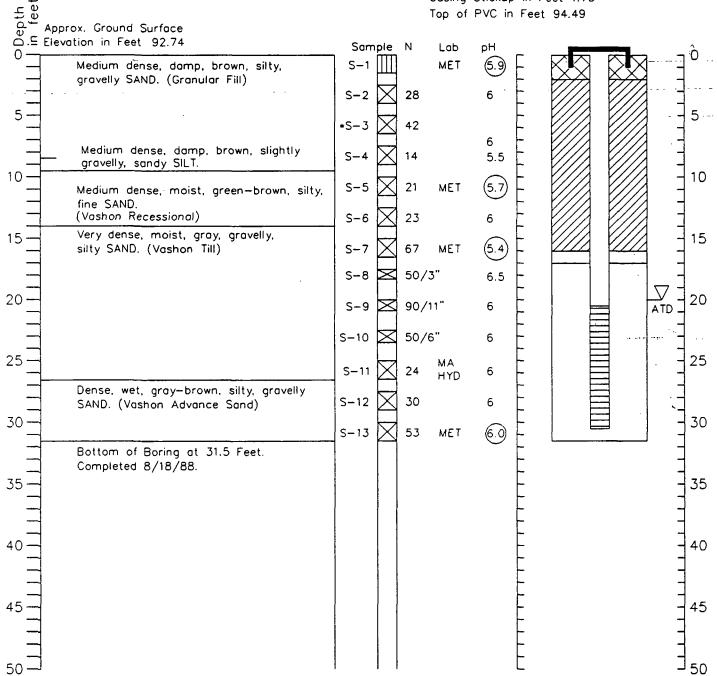
RTAROMSSER J-1824-32 8/88

Figure B-37.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.75 Top of PVC in Feet 94.49



<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.



Figure B-38.

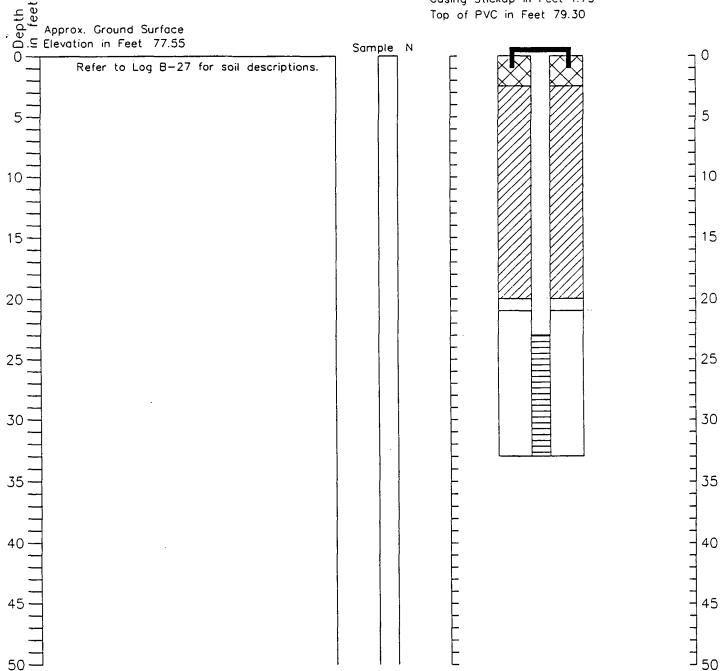
<sup>2.</sup> Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.75 Top of PVC in Feet 79.30



- 1. Refer to Figure B-1 for explanation of descriptions and symbols.
- 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- 3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

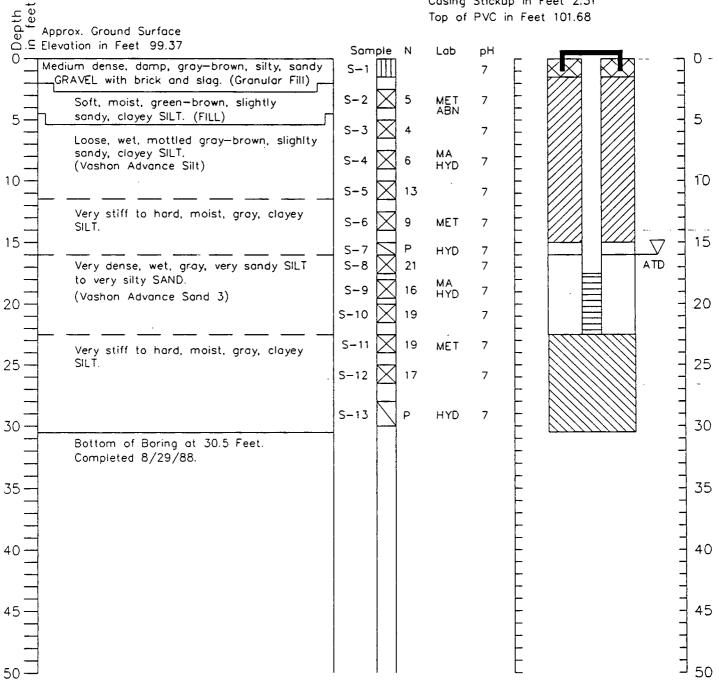


Figure B-39.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 2.31 Top of PVC in Feet 101.68



<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.

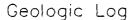
4. 2 inch split sampler with 300 lb. hammer.



Figure B-40.

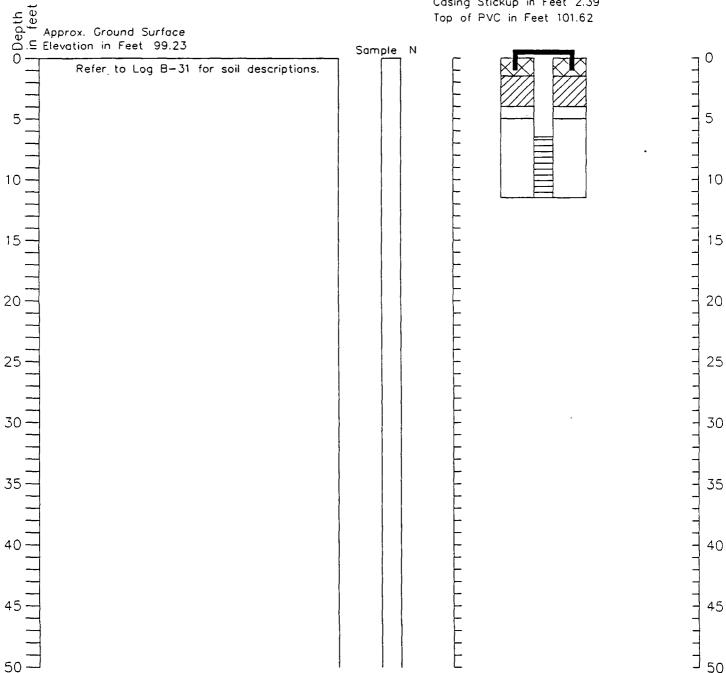
<sup>2.</sup> Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.



Monitoring Well Design

Casing Stickup in Feet 2.39 Top of PVC in Feet 101.62



<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.

2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.



J-1824-32

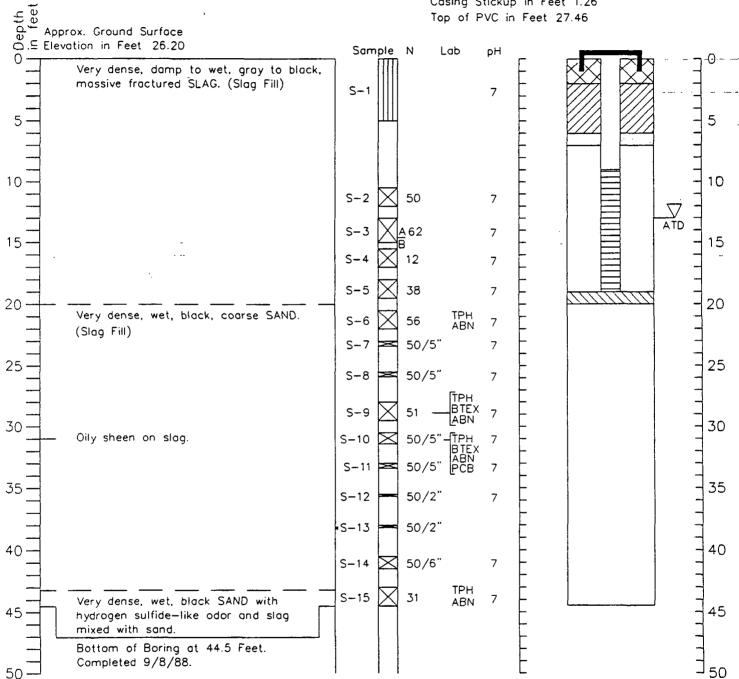
8/88

Figure B-41.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 1.26 Top of PVC in Feet 27.46



<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.



Figure B-42.

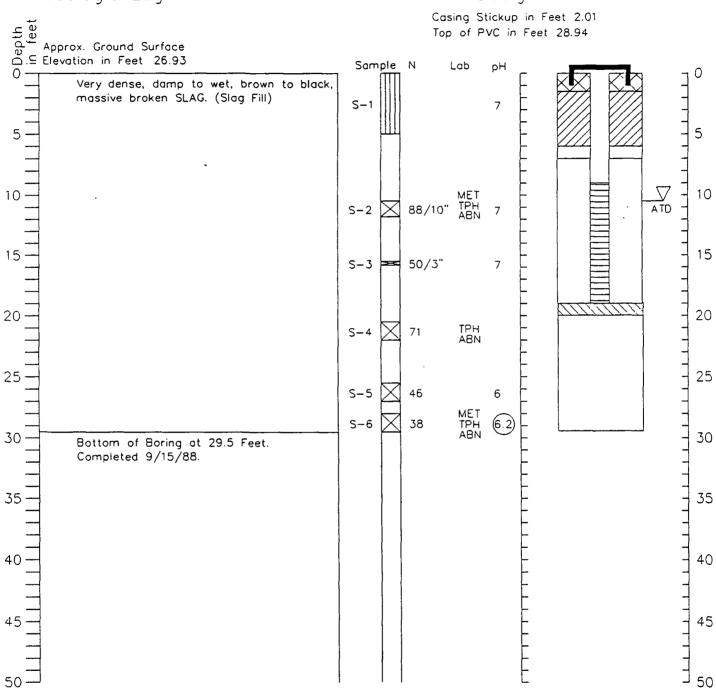
<sup>2.</sup> Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 2.01 Top of PVC in Feet 28.94



<sup>1.</sup> Refer to Figure B-1 for explanation of descriptions and symbols.

5. 3 inch split spoon sampler with 300 lb. hammer.



Figure B-43.

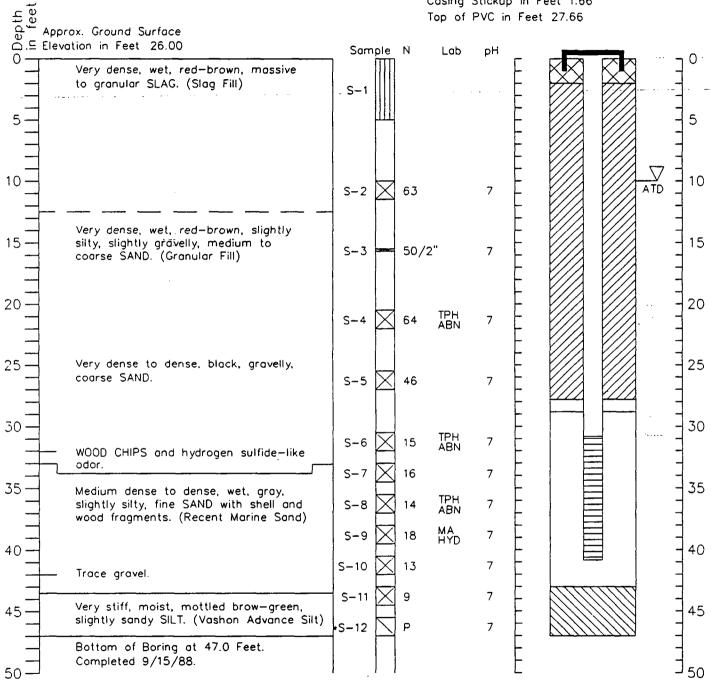
<sup>2.</sup> Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

<sup>3.</sup> Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time. 4. Odex drilling to 7 feet.

Geologic Log

Monitoring Well Design

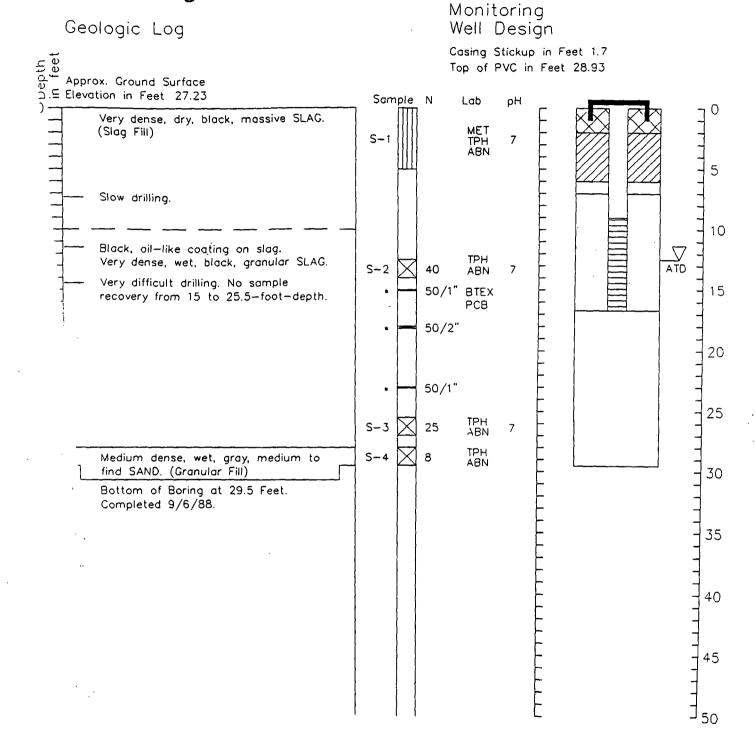
Casing Stickup in Feet 1.66 Top of PVC in Feet 27.66



- 1. Refer to Figure 8-1 for explanation of descriptions and symbols.
- 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- 3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
- 4. Odex drilling to 10 feet.
- 5. 2 inch split spoon sampler with 300 lb. hammer.



Figure B-44.



to Figure 8-1 for explanation of descriptions symbols.

tescriptions and stratum lines are interpretive actual changes may be gradual.

Id water level, if indicated, is at time of drilling 1 or for date specified. Level may vary with time. drilling to 10 feet.

I split spoon sampler with 300 lb. hammer.

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Figure B-45.

#### APPENDIX C

#### **EXISTING BORING INFORMATION**

Figure C-1 shows Phase I and II plus all known existing borings on the Asarco site. Figures C-2 through C-9 show boring logs for existing borings used to generate geologic cross-sections presented in Sections 3.5 and 3.6.

Geologic Log Well Design Casing Stickup in Feet 1.74 Approx. Ground Surface

C. Elevation in Feet 24.59 Top of PVC in Feet 26.33 Sample N Lab ρH 0 -Very dense, damp, dark gray, massive SLAG. (Slag Fill) MET ABN 5 Purple liquid on sampler with strong organic chemical odor. 9/18/88 10 Very dense, wet, black, fractured S-2 X ABN massive SLAG. Strong organic chemical odor. 15 15 S-3 57 4.5 WOOD CHIPS. 20 20 MET ABN 21 Dense, wet, gray, fine SAND. (Granular Fill) S-4 Bottom of Boring at 22.0 Feet. Completed 9/16/88. 25 30 35 40 45

Monitoring

4. Odex drilling to 11 feet.



50

Figure B-46.

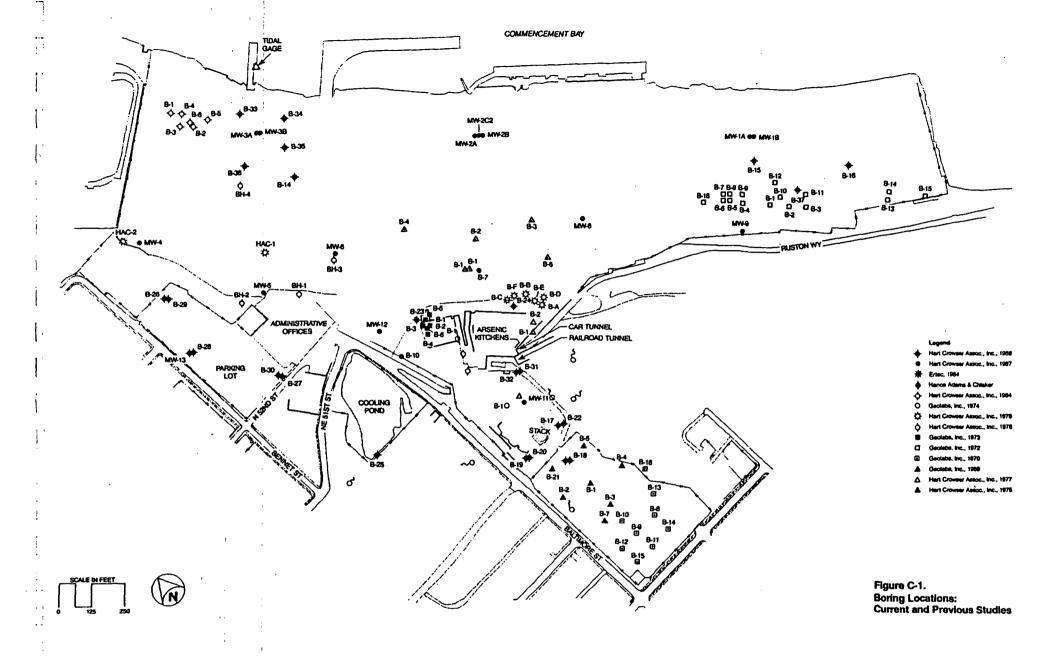
Refer to Figure B-1 for explanation of descriptions and symbols.

Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

<sup>5. 3</sup> inch split spoon sample with 300 lb. hammer.

# APPENDIX C EXISTING BORING INFORMATION



	DEPTH, fái	SC	SOIL DESCRIPTION	SAMPLES	PTH,fe.	STANDARD PENETRATION RESISTANCE— (140 lb. weight, 30"drop)  A Blows per foot		
	OE P	>	Surface Elevation:	SAR	DEP	0 25 50		
		SM	Medium dense, brown, silty, gravelly, medium SAND with many bricks and boards.					
-		SP	Medium dense, light yellow, moist, fine	II		•		
	- 5		SAND with some gravel.		ľ	<u> </u>		
		SM	Medium dense, brown to tan, moist, silty, fine SAND.	+				
-	-10-			+				
		SP	Medium dense, moist, tan to gray-tan, fine SAND with silt.	<del> </del>				
	15-		Negline stiff maint mottled to be because	+				
		ML	Medium stiff, moist, mottled, tan-brown SILT with fine sand.	F.				
	20 -	CL	Medium stiff, moist, blue-gray SILT to CLAY.	中				
	-25 -	ML SM	Medium stiff, moist, brown SILT layers with brown, silty, fine to medium SAND. (2" layers)	<del>  </del>				
	25			<del> </del>		61/12"		
	-30-	SP	Very dense, moist, brown to gray, fine SAND with some silt.	$+\dagger$	•	54/12"		
}								
	-35 -			<u> </u>		52/12"		
		ML CL	Medium stiff to stiff, moist, blue-gray SILT to CLAY.					
ļ	40			_				
	LEGEND % Water content  I 2.0" Q.D. split spoon sample   Impervious seal  II 3.0" Q.D. thin-wall sample   Water level   Tacoma Smelter - Stack Flue No. 1							
	* :	Sample berg li ————————————————————————————————————	not recovered Piezometer tip imits: P Sampler pushed limit USC Unitled Salt	Figur Log (	re ( of I			

DEPTH, 1251	กรต	SOIL DESCRIPTION Surface Elevation:	SAMPLES	DEPTH, 161		ICARD N RESISTANCE ht, 30"drop) per foot 25 50
c .		Garage Standion.	1	۴	4	
			IT			
45					$\nabla 1/4/74$	
45	-	· ·	"	L	$\nabla^{12/26/73}$	3
	ML	again, this he shift maigh blue man				
	CL	Medium stiff to stiff, moist, blue-gray SILT to CLAY.				<b>A</b>
-50-			-			/ .
		÷ ·				<b>A</b>
			-			1
			=	=		<b>^</b> .
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<u> </u> <u> </u>		1.505.115			· ]	<u> </u>
皿	3.0"	the state of the s	ma Sm	•	• % wer	Flue No. 1
*	Sampl	e not recovered <b>B</b> Mezometer IIp	Figu			}
A :ter		limits: P Sampler pushed Liquid limit USC Unified Sall	(Co	ntir	nued)_	. 1
1 <b>b</b> 1		Natural water content Classification Plastic limit			Boring B-1 plabs (1974)	

32

4.7

• •

DEPTH, 1001		SOIL DESCRIPTION	SAMPLES	PTH,feet	STANDARD PENETRATION RESISTANCE (140 lb. weight, 30"drop)
DEPT	ns.	Surface Elevation: 165'	SAN	DEPT	0 50 100
	sc	Medium dense, brown, clayey Sand with scattered gravel.	I		
.10.	SP.	Medium to very dense, brown to gray, fine to medium Sand.	I	10	
	-		I		
-20 -		Hard, gray, Clay and Silt.	I,	20	
	СН		I		•
.30	<del>-</del> -		Į:	30	
			Ŧ		
40.			F	40	
	ML	Word Crow C474	I		6
50 .		Hard, Gray, Silt.	l	50	7
			I		
60.	97		I 6	io	
	SP	Very dense, gray, slightly silty fine Sand; water bearing.	-		
- 70			I I	o	
	ML CH	Hard, gray, Clay and Silt.	- π		
80		LECEND	Щ.	801	20 40
II	3.0"	0.D. thin-wall sample			• % Water content elting & Refining Sept. 1969
	<b>→</b>	Liquid limit USC Unified Soil		of B	-3. Joring B-1 abs (1969)

. . . . . .

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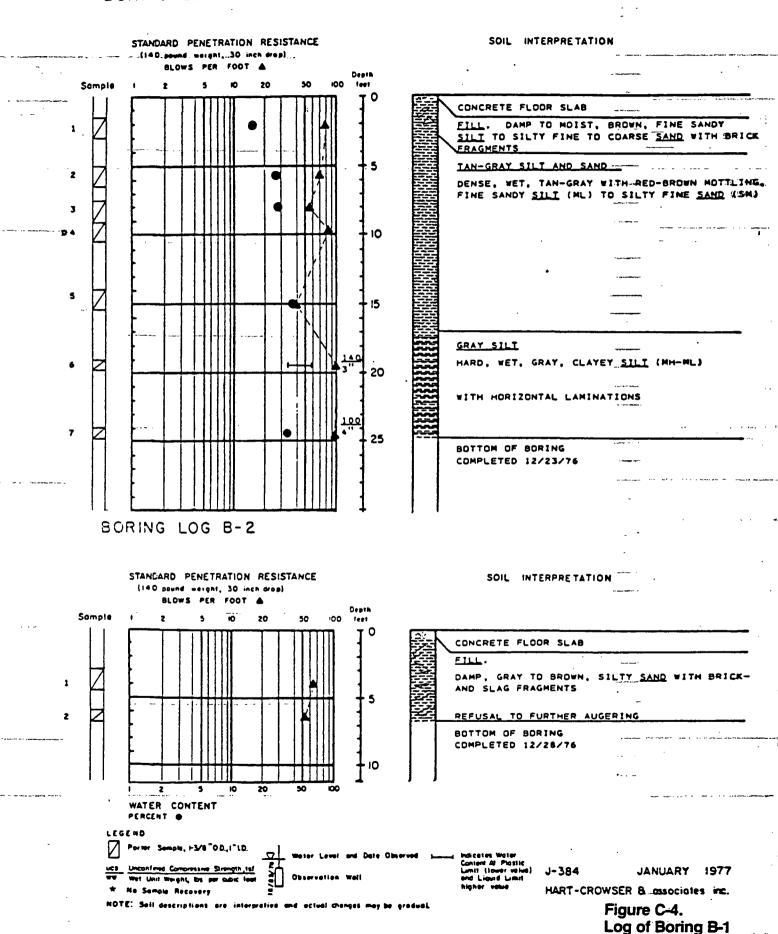
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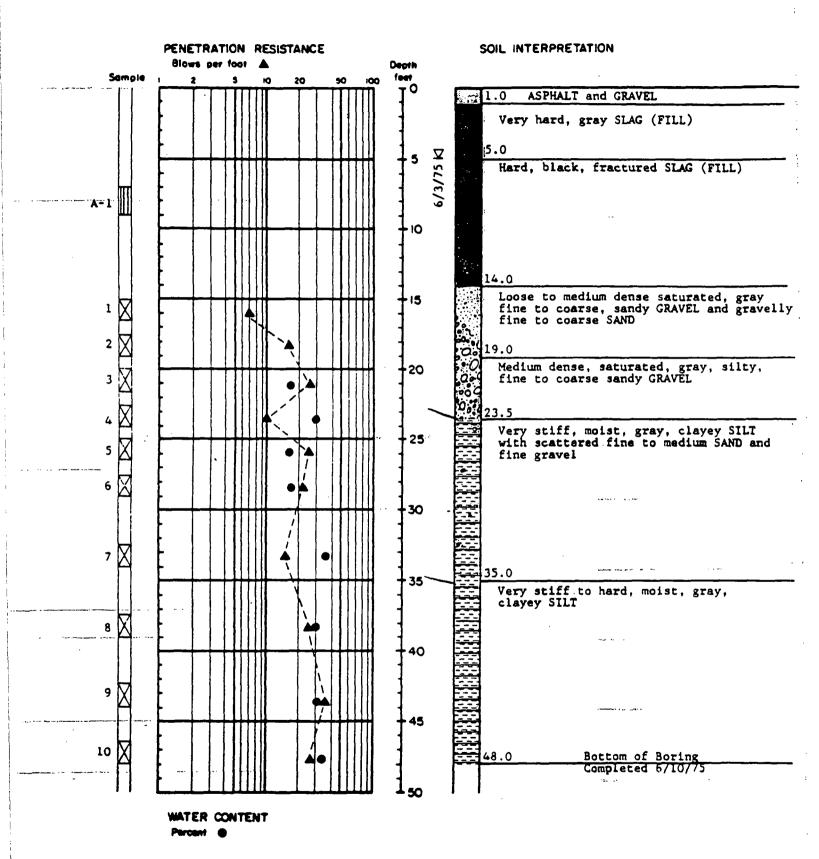
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. . . . .

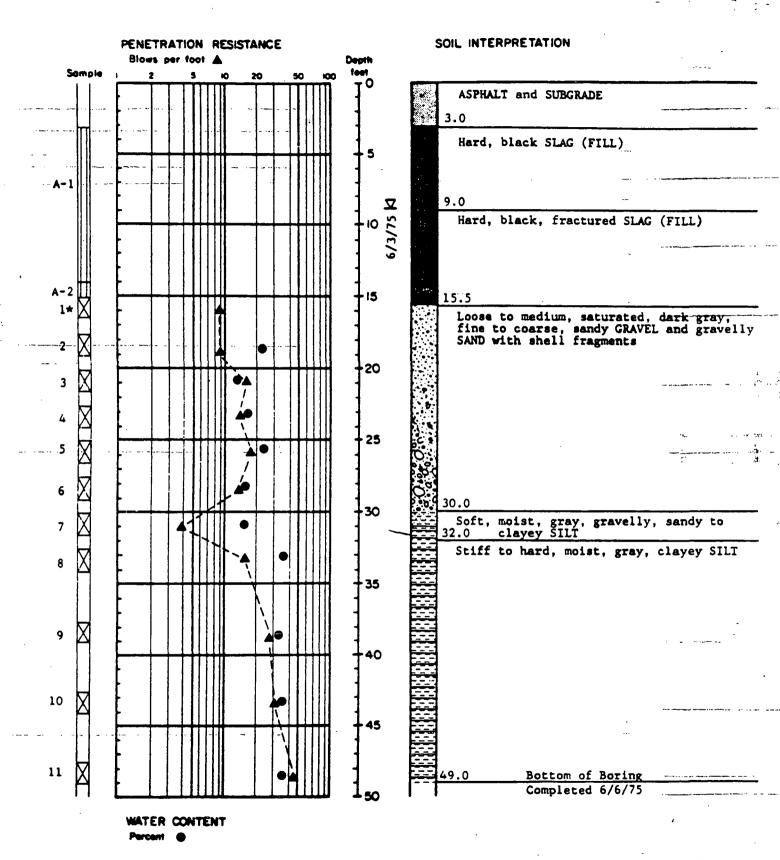
	DEPTH, 1001	nsc	SOIL DESCRIPTION  SURface Elevation: 165'  STANDARD PENETRATION RESISTAN (140 lb. weight, 30"drop)  A Blows per foot  50	CE
:		ML	Hard, gray, Clay and Silt	_
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The section was suspensed		]	T A	
	100		I 100	
			Bottom of boring @ 99-1/2 feet.	
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				JΓ
	_		LEGEND   Water content	40
	Щ	3.0"	D. split spoon sample   Impervious seel American Smelting & Refining O.D. thin-well sample   Water level W-251 Sept. 1969	
•	<b> </b> *	Sampl	e not recovered Piezometer tip Figure C-3.	
-			Continued)	
•		~	Natural water content Classification Log of Boring B-1 Plastic limit by Geolabs (1969)	

#### BORING LOG B-1

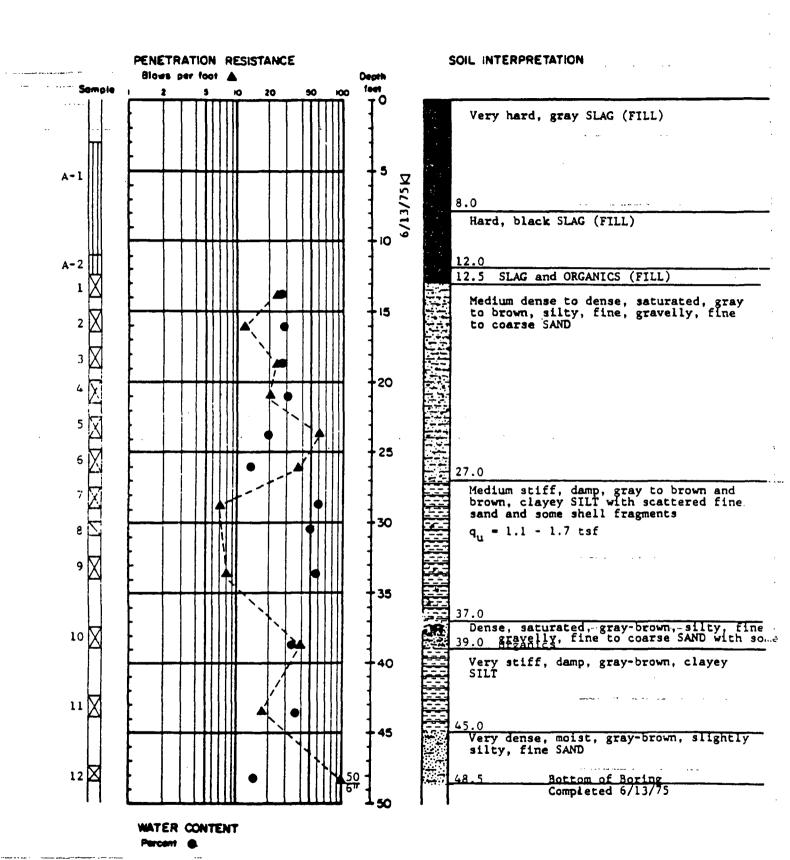




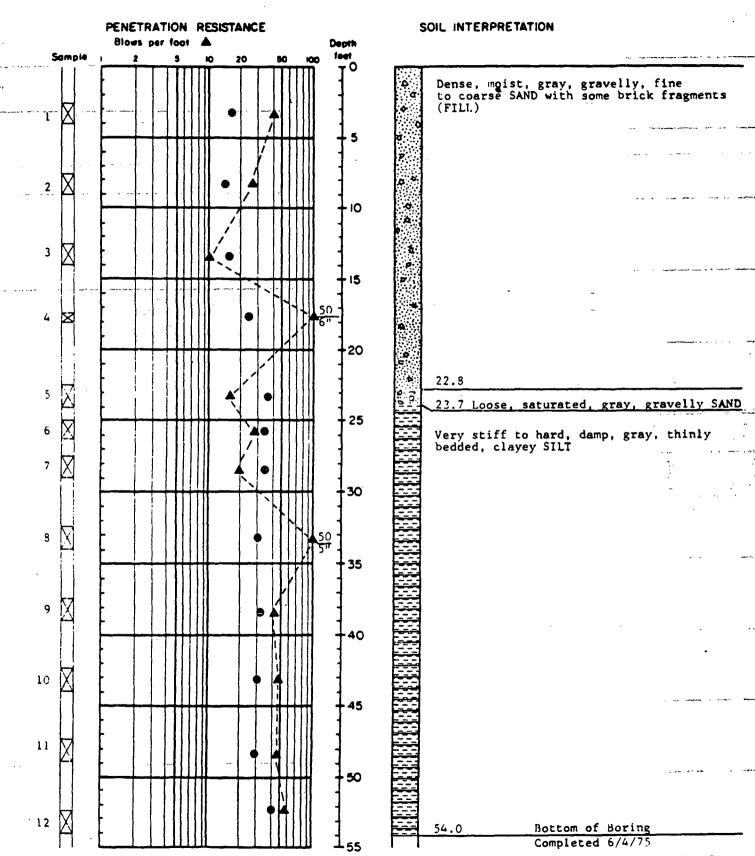
J-201 JUNE 1975
HART-CROWSER & desociates inc
Figure C-5.
Log of Boring B-2



J-201 JUNE 1975
HART-CROWSER & associates inc
Figure C-6.
Log of Boring B-3



J-201 JUNE 1975
HART-CROWSER & desociates inc.
Figure C-7.
Log of Boring B-4



J-201 JUNE 1975
HART-CROWSER & essociates inc.
Figure C-8.
Log of Boring B-6

### BORING LOG B-F

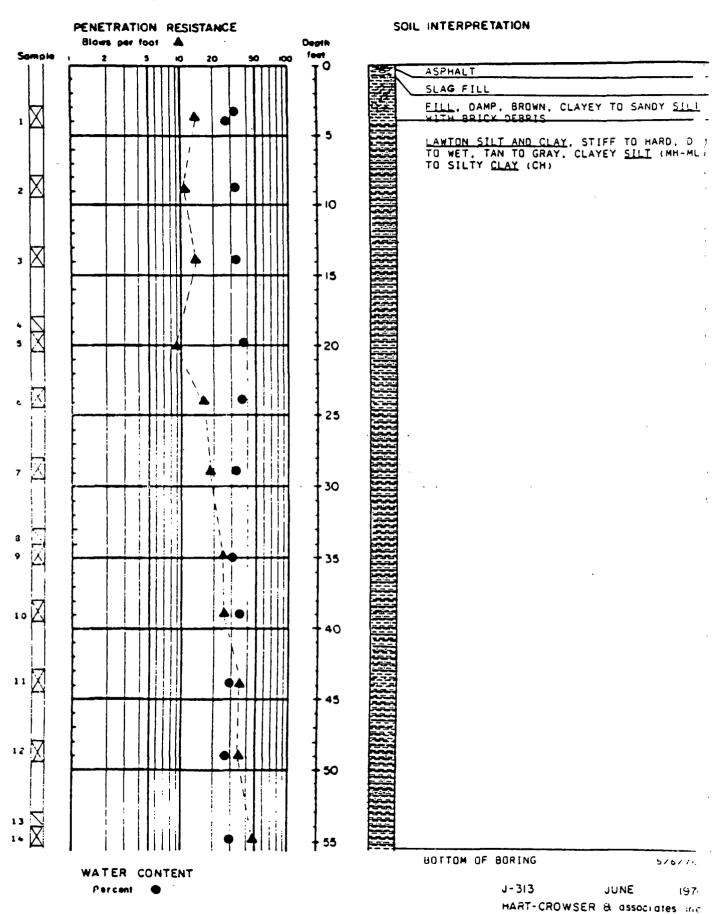


Figure C-9. Log of Boring B-F

## APPENDIX D

# LABORATORY TESTING PROGRAM FOR THE SUBSURFACE SOILS

#### APPENDIX D

### LABORATORY TESTING PROGRAM FOR THE SUBSURFACE SOILS

Three types of tests were performed in Hart-Crowser's laboratory. They were grain size analysis, hydraulic conductivity testing, and Asarco fill leachate testing. Descriptions of the test methods follow.

#### 1. Grain Size Analysis (GS)

Grain size distribution was analyzed on representative samples in general accordance with ASTM D 422 (Figure D-2). Wet sieve analysis was used to determine the size distribution greater than the U.S. No. 200 mesh sieve. The size distribution for particles smaller than the No. 200 mesh sieve was determined by the hydrometer method for a selected number of samples. The results of the tests are presented as curves on Figures E-2 through E-9 plotting percent finer by weight versus grain size.

#### 2. Hydraulic Conductivity Testing

Vertical hydraulic conductivities of fine-grained samples (e.g., samples from the Vashon Advance Silt) were measured using falling head permeameter tests in the Hart Crowser soil laboratory. Hydraulic conductivity tests were performed on relatively undisturbed Shelby tube soil samples. The soil samples were prepared by extruding the soil from the tube and trimming the desired length or shape of sample. For these samples, the hydraulic conductivity tests were performed in a triaxial cell using "flexible wall permeameter" techniques. Samples with vertical orientation were tested.

After trimming, the samples were placed in the triaxial cell, surrounded and sealed by rubber membranes. The samples were then consolidated using various cell water pressures selected to approximately equal in situ overburden pressure.

The hydraulic conductivity test was initiated after consolidation using water and falling head techniques. Hydraulic gradients of 5 to 15 were used. Flow occurred from the bottom of the sample to the top. The tests were continued until steady state flow occurred.

Summary of the laboratory hydraulic conductivity results are presented in Table 3-2.

### 3. Asarco Fill Leachate Testing

#### Introduction

The purpose of the leaching tests was to evaluate the release of trace metals from fill materials located on the Asarco Tacoma site. In order to determine whether these fill

materials may act as sources of metals to groundwater, we performed five leaching tests on selected soil and granular slag samples. Leachate testing consisted of passing pH-adjusted deionized water through a permeameter filled with soil or slag and measuring the changes in the water chemistry that resulted. Soil and slag samples were collected from seven test pits at locations presented on Figure 4-65. Five samples were chosen for leachate testing. Sampling methodology is discussed in Appendix B.

#### **Laboratory Apparatus**

- 8-inch-diameter acrylic double-ring permeameter with attached 10-gal acrylic reservoir (shown on Figure D-1)
- 100 percent Teflon non-woven filter fabric
- · Porous stone and stainless steel base
- · Teflon tubing and stainless steel needle valves
- Glass mariotte tubes
- 0.45  $\mu$  disposable filters
- 4-L plastic sample collection bottles

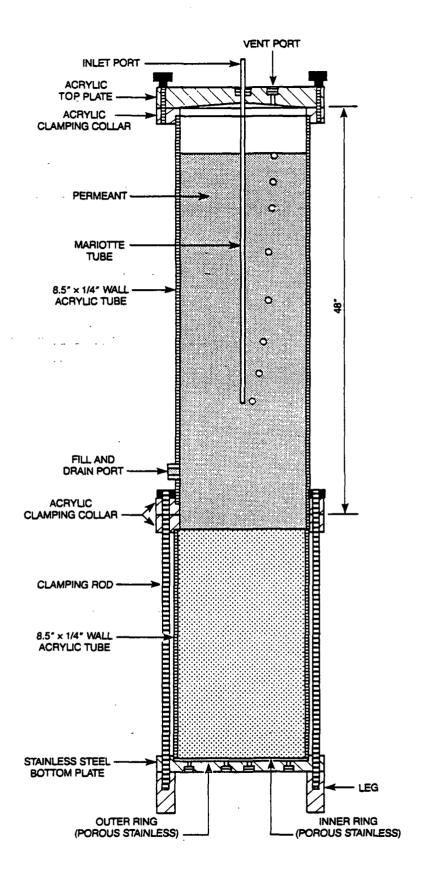
#### Test Procedure

### Step I: Water Preparation

A clean 50-gallon reservoir was filled with deionized water. A concentrated solution of reagent-grade calcium carbonate was added to the water reservoir until the pH of the deionized water was approximately 8. A sample of the pH-adjusted water was collected for dissolved trace metal analysis.

### Step II: Soil and Slag Preparation

Before placing the soil or slag fill into the permeameter, we collected representative samples of the fill for chemical (total and EPTox metals) and water content analyses (ASTM D-2216). The fill was loaded into the permeameter in 4 to 5 lifts having an average thickness of approximately 3 inches. The first lift was placed on top of a porous stone covered with Teflon filter fabric to prevent migration of fine (<0.075 mm) fill particles. Each lift was compacted by hand using a 3-inch-diameter hammer. After placing the fill into the permeameters, total fill area dimensions and weight were recorded and a determination of sample density, volume, and pore water was made. The 10-gal reservoirs were then placed on top of the permeameters.



#### **Features**

#### Large Size

Sample diameter of 8" and heights up to 12".

#### Double Drainage in Base

Flow from the central and outer portion of sample can be captured separately.

#### Stainless Steel Components

Base plate and porous drains are constructed of stainless steel to minimize contamination of permeant and interfering with leachate studies.

#### Permeant Reservoir

A large capacity (40 liter) reservoir is provided. Head loss through valves, fittings, etc. is eliminated by mounting the reservoir directly on top of the sample.

#### **Permeant Isolation**

The reservoir can be sealed from the atmosphere and nitrogen can be introduced through the top ports.

#### **Constant or Falling Head Tests**

The top plate of the reservoir is fitted with a mariotte tube for constant head testing. Falling head testing can be performed by removing the Mariotte tube.

Figure D-1.
Large Diameter Permeameter for Granular Materials

### Step III: Operation and Sampling

The pH-adjusted deionized water was pumped into the five permeameter reservoirs. We installed mariotte tubes in each of the reservoirs to regulate effective head (H) and water outflow (Q). Inner- and outer-ring outflow was also controlled by using stainless steel needle valves. Outflow was adjusted to allow approximately one pore volume per week to flow through the fill sample. Inner-ring outflow was filtered through an in-line  $0.45~\mu$  filter and collected in pre-labeled 4-L plastic sample bottles containing approximately 12 ml of nitric acid. Inner- and outer-ring sample bottles were calibrated to allow for determination of total flow and water sample volume. Flow was also monitored by measuring changes in water levels in the permeameter reservoirs. Flow rates were measured daily and adjusted when necessary. Inner-ring sample bottles were replaced after approximately one-half pore volumes had been collected. A total of five samples were collected from each permeameter. Outer-ring outflow was collected in 1-L sample bottles. The pH of outer-ring outflows were measured daily using an Orion pH meter.

Samples collected for dissolved trace metal analysis were stored in a large locked refrigerator until shipment to Asarco's Salt Lake City laboratory.

### Unified Soil Classification (USC) System

### Soil Grain Size

	,	31 <b>2</b> 0	af	Οŧ	en:	ing	ir	1 ]	nc	hes				NU	ber	of US	Me: Sta	sh p	rd)	In	ch			Gr	eir	Size	11	3 1	41	110	etr	<b>.</b> 88	
~		•	•		2		_		1/2	3	3/1	•		9		20		\$	9		2	5	8	3	9.	20.	10.	.00	900.	00	.003	200	
		T	T T	11		1_	1	1 1	T	11		1	1 !	1		111	11.	T LL	.1.	1	1	111	T I	1 T	1	1	11			1	-1 -		
300	200		0 0	90		8			-	2 (	•	,	• 0	~		- •	•	_	ŗ	u.		- 8	80.	ŏ	.03	<b>2</b> 0.	ē	80	800	<b>*</b> 00.	.003		- 6

#### Grain Size in Millimetres

COSSLES	GRAVEL	SAND	SILT and CLAY					
Coarse-Grained Soils Fine-Graine								

### Coarse-Grained Soils

G W	GP	6 M	e c	SW	SP	SM	SC
Clean GRAVE	L <5% fines	GRAVEL With	>12% fines	Clean SAND	<5% fines	SAND with	>12% fines
GRAVEL >50	% coarse fra	ction larger	than No. 4	XOE< CINAS	coarse frac	tion smaller	than No. 4
	C	oarse <del>-G</del> rained	Soils >50%	larger than	No. 200 siev	8	

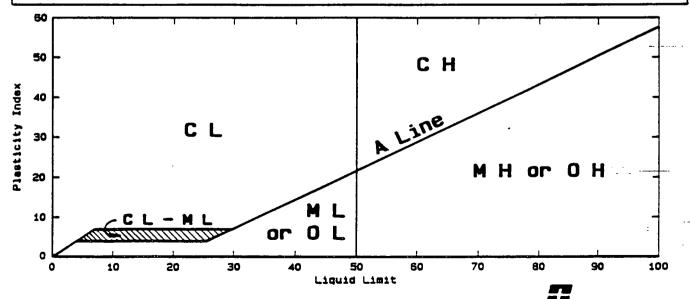
6 W and S W = 
$$\left(\frac{D_{60}}{D_{10}}\right)$$
 >4 for 6 W & 1 $\leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right)$   $\leq$  3 G P and S P Clean SPAVEL or SAND not meeting requirements for 6 W and S W

- 6 M and S M Atterberg limits below A Line with PI <4
- G C and S C Atterberg limits above A Line with PI >7
- \* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

 $D_{10}\,.$   $D_{30},$  and  $D_{60}$  are the particle diameter of which 10. 30, and 60 percent, respectively, of the soil weight are finer.

### Fine-Grained Soils

		MH	C H	ОН	
CLAY	Organic	SILT	CLAY	Organic	Highly
with Liquid Limi	<50%	Soils w	it >50%	Organic Soils	
	th Liquid Limit	th Liquid Limit <50%	th Liquid Limit <50% Soils w		th Liquid Limit <50% Soils with Liquid Limit >50%

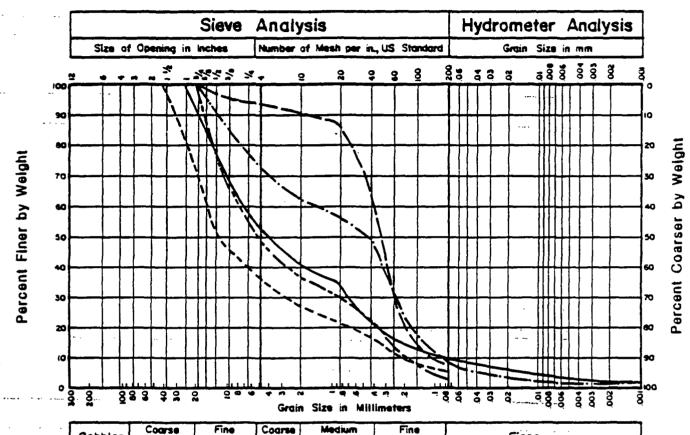


HARTCROWSER

J-1824-60 2/89

Figure D-2.

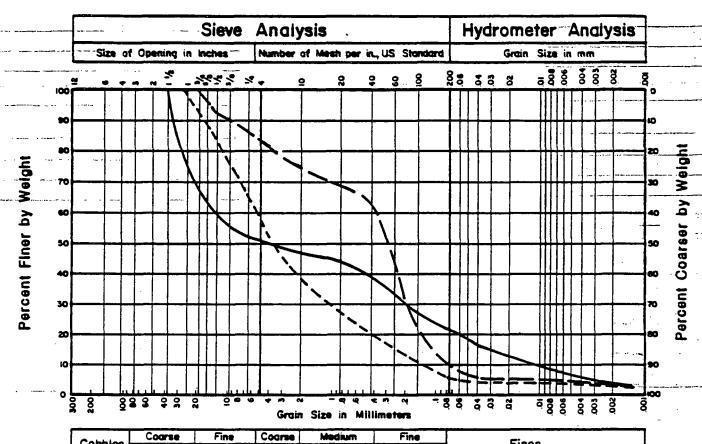
# Grain Size Classification Plant Area-Screened Zones



	Cobbles	-04.30		(100 medicin		Fines		· ·
	Coppies	Gravel		Sand		rille3	· · · · · · · · · · · · · · · · · · ·	
LINE SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH IN FEET	CLASSIF	FICATION		UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
	MW - 4	S-7	16.0 - 17.5	Slight GRAVEL	tly silty,	very sandy	GP-GM	9
<del></del>	Mis 4	S-10	23.5 - 25.0	J.,	:ly gravell , medium to	ly, slightly o fine SAND.	SP-SM	19
	MW-5	S-12	28.5 - 29.0	S1 i ght GRAVEL	:ly silty,	very sandy	GW-GM	8
<u></u>	₩-8	S <b>-</b> 9	20.0 - 21.5	Slight SAND.	tly silty,	gravelly	SP-SM	13
	8-MM	S-11	25.0 - 26.5	Very s	andy GRAVE	īL.	GP	11



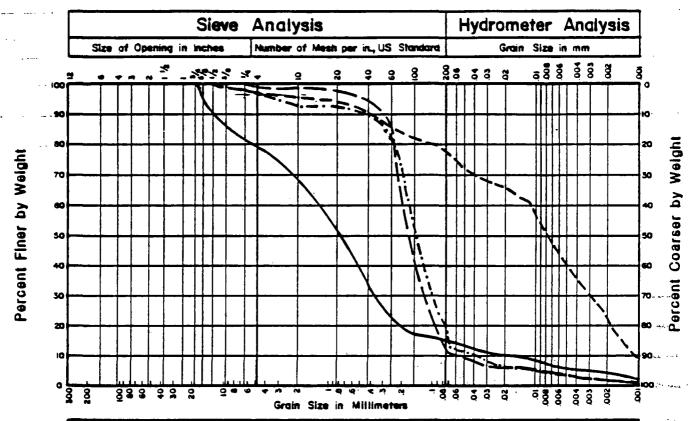
# Grain Size Classification Plant Area-Screened Zones



į	Copples	Gravel		Sand	Fines		
LINE	BORING	SAMPLE NUMBER	DEPTH IN FEET	CLASSIFICATION		UNIFIED SOIL CLASS	WATER CONTENT_ PERCENT_
	Mwi-6	S-13A	31.0 <b>-</b> 31.5	Slightly silty, gravel	lly SAND	SP-SM	16
<del></del>	M∵-9	S <b>-</b> 6	15.0- 16.5	Slightly silty, gravel	lly SAND	SP-SM	28
	- MW-12	S-16	38.5- 40.0	Slightly silty, very s	gravelly	SVI-SM	14



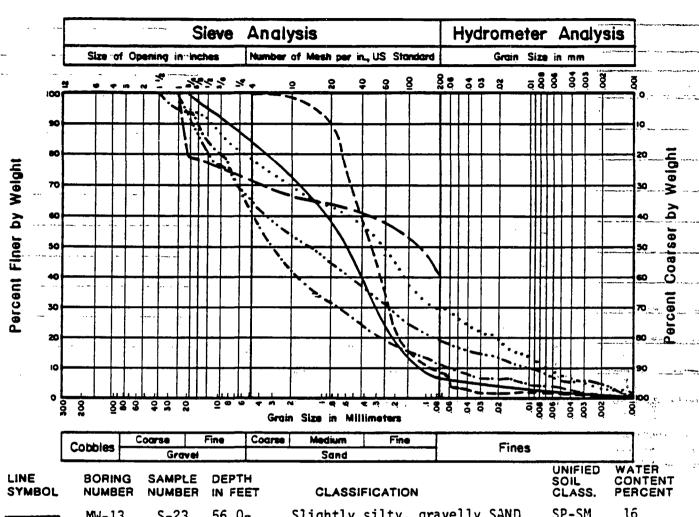
# Grain Size Classification Plant Area-Screened Zones



	Cabbles	Course	Fine Cod	ree Medium	Fine	Fines		
	Cobbles	Grave	4	Sand		Fines		
LINE SYMBOL	BORIN			CLASSI	FICATION		UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
	B-14	S-25	71.0- 72.0	Silty, gr	avelly SA	ND	SM	15
	B-16	S <b>-</b> 6	28.0 <del>-</del> 29.5	Slightly	silty, fi	ne SAND	SM	25
	- B-25	S <b>-</b> 8	17.5- 19.0	Sandy, cl	ayey SILT		ML	41
	- 8-35	<b>S-9</b>	38.0 <del>-</del> 39.5	Silty, fi	ne SAND		SM	22



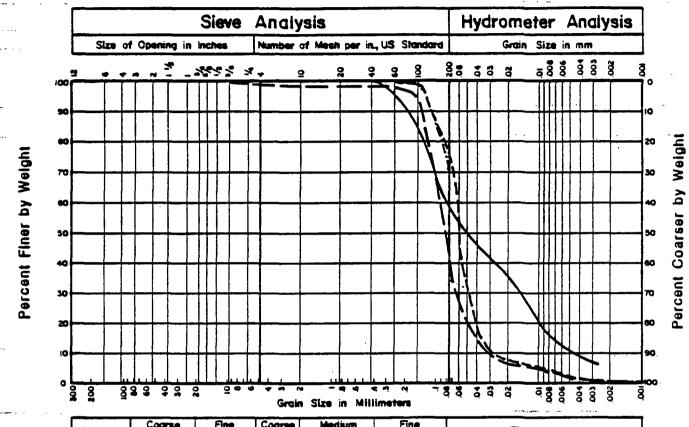
# Grain Size Classification Parking Lot Area-Screened Zones



	Copples	Gravei		Sand	Fines		
LINE SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH IN FEET	CLASSIFICATION		UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
	MW-13	S-23	56.0 <del>-</del> 57.5	Slightly silty, gravell	y SAND	SP-SM	16
	3-26	S-3	35.0 <del>-</del> 36.0	Very silty, sandy GRAVE	ïL	GM	15
	B-27	S-11	25.5- 27.0	Slightly silty, medium SAND	to fine	SP-SM	8
	B-27	S-26	62.5- 63.0	Slightly silty, very gr	avelly	SW-SM	8
	B-28	S-13	30.0- 30-5	Slightly clayey, silty, gravelly SAND	very	SM	7
• • • • • •	B-29	S <b>-</b> 11	25.5- 26.5	Gravelly, silty SAND		SM	19

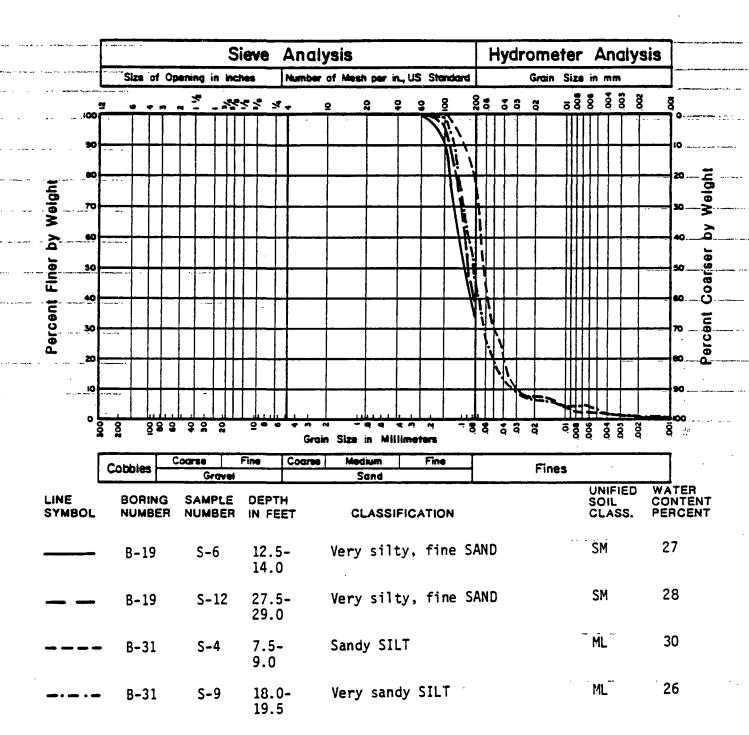
HART CROWSER
J-1824-60 2/89
Figure D-6.

# Grain Size Classification Stack Area-Screened Zones



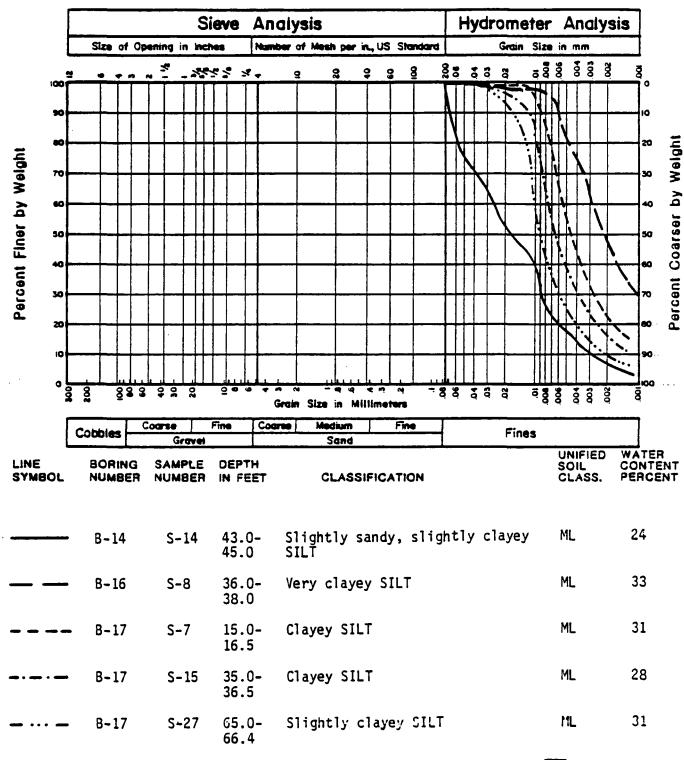
1	Cobbles	Course	1 1.	CHITE	Codisa	MARCH LAND		rine		Fines		1
į	Copples		Gravel			Sand			1	F11183		
LINE SYMBOL	BORIN	-	APLE ABER	DEPTI	-	CLASS	IIFICA	TION			UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
<del></del>	MW-1	.1 S	<b>-</b> 7	15.5 17.0		Slightly	/ cla	yey,	sandy S1	LT	ML	26
	<b>-</b> B-17	' s	<b>-</b> 3	5.0 <b>-</b> 6.5		Very sil	lty,	fine	SAND		SM	8
	<b>-</b> B-17	7 S	<del>-</del> 25	60.0 62.5		Sandy S	[LT		me, j.		ML	26
	<b>-</b> B-18	3 S	-20	47.5 49.0		Sandy S	ILT		<del></del>		ML	29

## Grain Size Classification Stack Area-Screened Zones



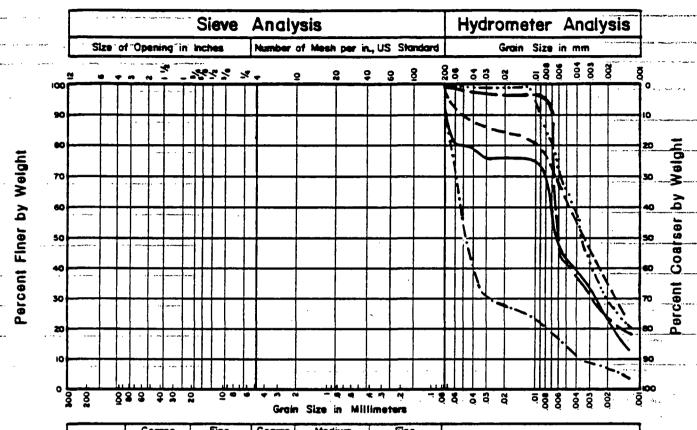


## **Grain Size Classification Aquitard Zones**



HARTCROWSER
J-1824-60 2/89
Figure D-9.

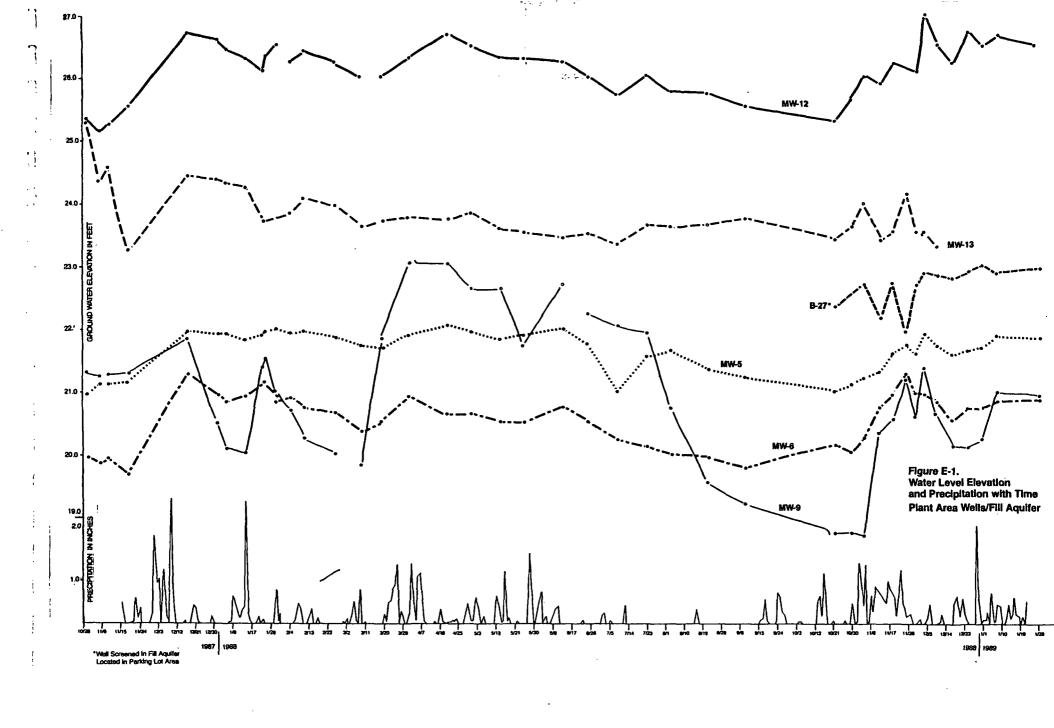
# **Grain Size Classification Aquitard Zones**

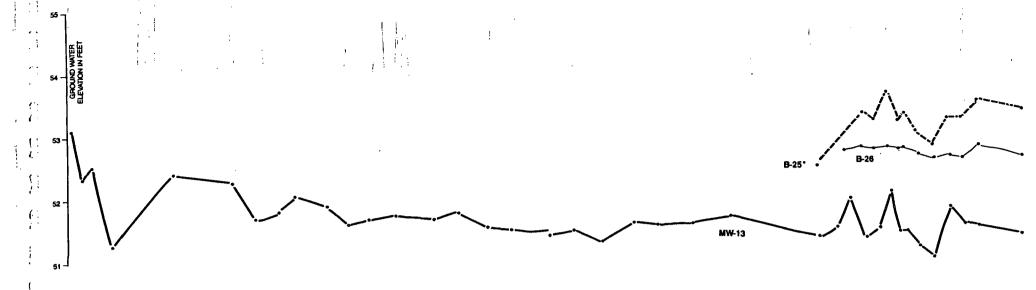


i	Cobbles	Coarse	Fine Coarse	Medium	Fine	Fines		,
1	Copples	Gravel		Sand		rines		
LINE SYMBOL	BORING NUMBE		DEPTH IN FEET	CLASSII	FICATION		UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
	B-31	S-13	28.0- 30.5	Clayey SI	LT		ML	31
	B-18	S <b>-</b> 6	12.0- 14.0	Slightly	sandy, cla	yey SILT	ML	30
	- B-23A	s-2	18.5- 18.8	Clayey SI	[LT		ML	41
	- B-25R	S-1	23.7- 24.0	Very clay	ey SILT		ML	40
<b> ··· ·</b>	B-31	S-7	15.0- 16.0	Slightly SILT	clayey, sl	ightly sandy	ML	29



APPENDIX E	
GROUNDWATER ELEVATION AND PRECIPITATION GRAPHS	
The second secon	
	Garage (1917) in the second
	<b>以</b> 是到16年16年





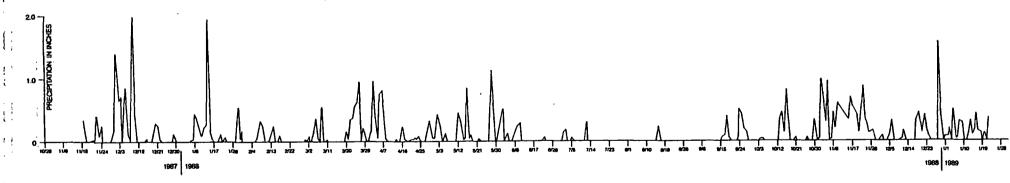


Figure E-2.
Water Level Elevation
and Precipitation with Tin
Parking Lot Area Wells/
Glacial Drift Sequence

\*Aquiller not Differentiated Located in Plant Area

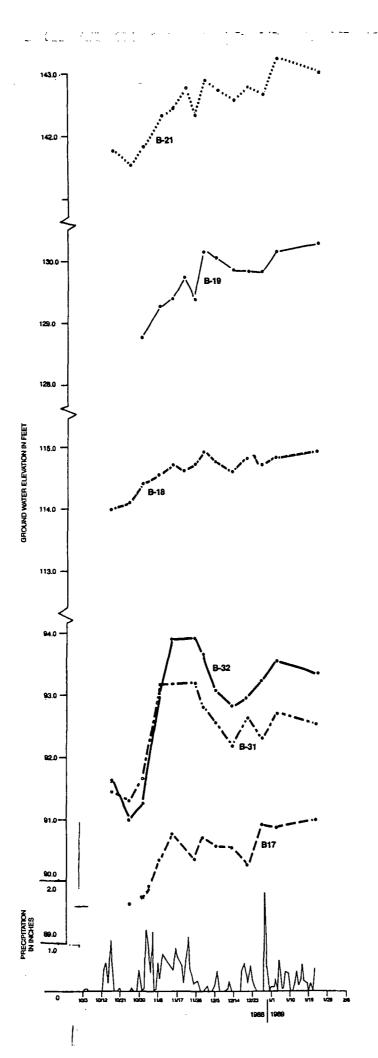


Figure E-3. Water Level Elevation and Precipitation with Time Stack Area Wells/ Vashon Advance Aquifers

# APPENDIX F TECHNICAL DATA SUMMARIES

Table F-1. Summary of Surface Water Constituent Concentrations (Base Neutrals).

	Detection	Minimum Value	Maximum Value	Mean of All Values
PARAMETER	Frequency	(ppm)	(ppm)	(ppm)
Acenaphthene	0/28	< 10.00	< 40.00	12.50
Acenaphthylene	0/28	< 10.00	< 40.00	12.50
Aniline	0/28	< 10.00	< 40.00	12.50
Anthracene	0/28	< 10.00	< 40.00	12.50
Benzidine	0/28	< 80.00	< 300.00	100.71
Benzo(a)anthracene	0/28	< 10.00	< 40.00	12.50
Benzo(a) pyrene	0/28	< 10.00	< 40.00	12.50
Benzo(b) flouranthene	0/28	< 10.00	< 40.00	12.50
Benzo(g,h,i)perylene	0/28	< 10.00	< 40.00	12.50
Benze(k) fluoranthene	0/28	< 10.00	< 40.00	12.50
Benzyl Alcohol	0/28	< 10.00	< 40.00	12.50
bis(2-chloroethoxy)methane	0/28	< 10.00	< 40.00	12.50
bis(2-chloroehtyl)ether	0/28	< 10.00	< 40.00	12.50
bis(2-chloroisopropyl)ehter	0/28	< 10.00	< 40.00	12.50
bis(2-ethylhexyl)phthalate	3/28	< 10.00	110.00	16.42
4-Bromophenyl-phenyl ether	0/28	< 10.00	< 40.00	12.50
Butyl benzyl phthalate	0/28	< 10.00	< 40.00	12.50
4-Chloroaniline	0/28	< 10.00	< 40.00	12.50
2-Chloronaphthalene	0/28	< 10.00	< 40.00	12.50
4-Chlorophenyl phenyl ether	0/28	< 10.00	< 40.00	12.50
Chrysene	0/28	< 10.00	< 40.00	12.50
Dibenzo(a,h)anthracene	0/28	< 10.00	< 40.00	12.50
Dibenzofuran	0/28	< 10.00	< 40.00	12.50
1,2-Dichlorobenzene	0/28	< 10.00	< 40.00	12.50
1,3-Dichlorobenzene	0/28	< 10.00	< 40.00	12.50
1,4-Dichlorobenzene	0/28	< 10.00	< 40.00	12.50
3,3-Dichlorobenzidine	0/28	< 10.00	< 40.00	12.50
Diethyl phthalate	0/28	< 10.00	< 40.00	12.50

Table F-1. Summary of Surface Water Constituent Concentrations (Base Neutrals) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
-:	2 (2 2	- 10 00		
Dimethyl phthalate	0/28	< 10.00	< 40.00	12.50
Di-n-Butyl phthalate	1/28	< 10.00	30.00	13.21
2,4-Dinitrotoluene	0/28	< 10.00	< 40.00	12.50
2,6-Dinitrotoluene	0/28	< 10.00	< 40.00	12.50
Di-n-Octyl phthalate	0/28	< 10.00	< 40.00	12.50
Fluoranthene	1/28	< 10.00	30.00	13.21
Fluorene	0/28	< 10.00	< 40.00	12.50
Hexachlorobenzene	0/28	< 10.00	< 40.00	12.50
Hexachlorobutadiene	0/28	< 10.00	< 40.00	12.50
Hexachlorocyclopentadiene	0/28	< 10.00	< 40.00	12.50
Hexachloroethane	0/28	< 10.00	< 40.00	12.50
Indeno(1,2,3-cd)Pyrene	2/28	< 10.00	10.00	12.50
Isophorone	0/28	< 10.00	< 40.00	12.50
2-Methylnaphthalene	0/28	< 10.00	< 40.00	12.50
Naphthalene	0/28	< 10.00	< 40.00	12.50
2-Nitroanaline	0/28	< 10.00	< 40.00	12.50
3-Nitroanaline	0/28	< 10.00	< 40.00	12.50
4-Nitroanaline	0/28	< 10.00	< 40.00	12.50
Nitrobenzene	0/28	< 10.00	< 40.00	12.50
N-Nitrosodimethylamine	0/28	< 10.00	< 40.00	12.50
N-Nitrosodipropylamine	0/28	< 10.00	< 40.00	12.50
N-Nitrosodiphenylamine(1)	0/28	< 10.00	< 40.00	12.50
Phenanthrene	0/28	< 10.00	< 40.00	12.50
Pyrene	0/28	< 10.00	< 40.00	12.50
1,2,4-Trichlorobenzene	0/28	< 10.00	< 40.00	12.50
2-methyl-4,6-dinitrophenol	0/28	< 10.00	< 40.00	12.50
PCB's	0/26	< 1.00	< 5.00	2.61

Table F-1. Summary of Surface Water Constituent Concentrations (Acids) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Page 1 - Agid	0./20	<b>450.00</b>	<200.00	62.50
Benzoic Acid	0/28	<50.00	<200.00 <40.00	12.50
2-Chlorophenol	0/28	<10.00		•
2,4-Dichlorophenol	0/28	<10.00	<40.00	12.50
2,4-Dimethylphenol	0/28	<10.00	<40.00	12.50
2,4-Dinitrophenol	0/28	<50.00	<200.00	62.50
2-Methylphenol	0/28	<10.00	<40.00	12.50
4-Methylphenol	0/28	<10.00	<40.00	12.50
2-Nitrophenol	0/28	<10.00	<40.00	12.50
4-Nitrophenol	0/28	<50.00	<200.00	62.50
4-Chloro-3-methylphenol	0/28	<10.00	<40.00	12.50
Pentachlorophenol	0/28	<50.00	<200.00	62.50
Phenol	0/28	<10.00	<40.00	12.50
2,4,5-Trichlorophenol	0/28	<50.00	<200.00	62.50
2,4,6-Trichlorophenol	0/28	<10.00	<40.00	12.50
Biphenyls	0/28	<10.00	<40.00	12.50
Dibenzothiophene	0/28	<10.00	<40.00	12.50
Dimethylanaline	0/28	<10.00	<40.00	12.50
Methylphenanthrenes	0/28	<10.00	<40.00	12.50
1 methyl (2-methylethyl) benzine	0/28	<10.00	<40.00	12.50

Table F-1. Summary of Surface Water Constituent Concentrations (Metals) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Antimony (T)	40/72	< 0.08	0.600	0.115
- • •	•	< 0.08	0.313	0.088
Antimony (D)	28/70		43.800	1.810
Arsenic (T)	69/72	< 0.004		
Arsenic (D)	67/70	< 0.004	3.250	0.324
Cadmium (T)	61/72	< 0.001	0.350	0.032
Cadmium (D)	55/70	< 0.001	0.338	0.018
Copper (T)	69/72	< 0.008	28.800	2.714
Copper (D)	68/70	< 0.008	17.750	0.800
Lead (T)	67/72	< 0.005	8.500	0.493
Lead (D)	42/70	< 0.005	0.075	0.013
Mercury (ppb) (T)	40/72	< 0.500	230.000	8.158
Mercury (ppb) (D)	1/70	0.500	0.500	0.500
Nickel (T)	27/72	< 0.03	0.300	0.055
Nickel (D)	20/70	< 0.03	0.160	0.042
Zinc (T)	70/72	< 0.008	21.600	1.218
Zinc (D)	69/70	< 0.008	20.400	0.950

Table F-2. Summary of Surficial Soils Constituent Concentrations (Base Neutrals).

	Detection	Minimum Value	Maximum Value	Mean of All Values
PARAMETER	Frequency	(ppm)	(ppm)	(ppm)
Acenaphthene	22/93	< 300.00	2690.00	1885.26
Acenaphthylene	3/93	< 300.00	800.00	1645.69
Aniline	0/93	< 300.00	< 20000.00	1639.24
Anthracene	24/93	< 300.00	40000.00	2491.39
Benzidine	0/93	< 520.00	< 50000.00	12988.70
Benzo(a)anthracene	35/93	< 300.00	108000.00	4503.97
Benzo(a)pyrene	34/93	< 300.00	72000.00	3735.91
Benzo(b)flouranthene	37/93	< 300.00	39700.00	4679.35
Benzo(g,h,i)perylene	30/93	< 300.00	48000.00	2642.25
Benzo(k)fluoranthene	9/93	< 300.00	2960.00	1649.56
Benzyl Alcohol	0/93	< 300.00	< 20000.00	1639.24
ois(2-chloroethoxy)methane	0/93	< 300.00	< 20000.00	1639.24
ois(2-chloroehtyl)ether	0/93	< 300.00	< 20000.00	1639.24
ois(2-chloroisopropyl)ehter	0/93	< 300.00	< 20000.00	1639.24
ois(2-ethylhexyl)phthalate	5/93	< 300.00	790.00	1629.78
4-Bromophenyl-phenyl ether	0/93	< 300.00	< 20000.00	1622.04
Butyl benzyl phthalate	0/93	< 300.00	< 20000.00	1622.04
4-Chloroaniline	0/93	< 300.00	< 20000.00	1639.24
2-Chloronaphthalene	0/93	< 300.00	< 20000.00	1639.24
4-Chlorophenyl phenyl ether	0/93	< 300.00	< 20000.00	1622.04
Chrysene	39/93	< 300.00	112000.00	4634.08
Dibenzo(a,h)anthracene	9/93	< 300.00	2860.00	1699.89
Dibenzofuran	13/93	< 300.00	7200.00	1829.89
1,2-Dichlorobenzene	0/93	< 300.00	< 20000.00	1639.24
1,3-Dichlorobenzene	1/93	< 300.00	700.00	1643.22
1,4-Dichlorobenzene	10/93	< 300.00	1350.00	1736.98
3,3-Dichlorobenzidine	0/93	< 660.00	< 40000.00	3332.25
Diethyl phthalate	0/93	< 300.00	< 20000.00	1622.04

Table F-2. Summary of Surficial Soils Constituent Concentrations (Base Neutrals) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Dimethyl phthalate	3/93	< 300.00	1520.00	1651.61
Di-n-Butyl phthalate	0/93	< 300.00	< 20000.00	1622.04
2,4-Dinitrotoluene	10/93	< 300.00	1630.00	1720.21
2,6-Dinitrotoluene	1/93	< 300.00	610.00	1637.60
Di-n-Octyl phthalate	0/93	< 300.00	< 20000.00	1622.04
Fluoranthene	39/93	< 300.00	169000.00	7301.93
Fluorene	19/93	< 300.00	31000.00	2151.72
Hexachlorobenzene	0/93	< 300.00	< 20000.00	1622.04
Hexachlorobenzene Hexachlorobutadiene	0/93	< 300.00	< 20000.00	1639.24
Hexachlorocyclopentadiene	0/93	< 300.00	< 20000.00	1639.24
Hexachloroethane	0/93	< 300.00	< 20000.00	1639.24
Indeno(1,2,3-cd)Pyrene	28/93	< 300.00	39000.00	2418.81
Isophorone	1/93	< 300.00	560.00	1640.96
2-Methylnaphthalene	15/93	< 300.00	36000.00	1950.75
Naphthalene	16/93	< 300.00	69000.00	2568.06
2-Nitroanaline	0/93	< 1700.00	< 100000.00	8091.39
3-Nitroanaline	3/93	< 1700.00	11900.00	8132.79
4-Nitroanaline	0/93	< 1700.00	< 100000.00	8016.12
Nitrobenzene	0/93	< 300.00	< 20000.00	1639.24
N-Nitrosodimethylamine	0/93	< 300.00	< 20000.00	1687.63
N-Nitrosodipropylamine	10/93	< 300.00	1400.00	1727.95
N-Nitrosodiphenylamine(1)	1/93	< 300.00	1390.00	1633.44
Phenanthrene	39/93	< 300.00	265000.00	8180.53
Pyrene	48/93	< 300.00	277000.00	9373.76
1,2,4-Trichlorobenzene	10/93	< 300.00	1700.00	1751.29
2-methyl-4,6-dinitrophenol	0/93	< 900.00	< 100000.00	7992.47
PCB's	20/93	< 200.00	11200.00	2324.51

Table F-2. Summary of Surficial Soils Constituent Concentrations (Acids) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
			VE P /	VPP/
Benzoic Acid	1/93	<2000.00	2310.00	8092.47
2-Chlorophenol	10/93	<400.00	3130.00	1851.93
2,4-Dichlorophenol	0/93	<400.00	<20000.00	1639.24
2,4-Dimethylphenol	0/93	<400.00	<20000.00	1639.24
2,4-Dinitrophenol	0/93	<2000.00	<90000.00	7992.47
2-Methylphenol	0/93	<400.00	<20000.00	1639.24
4-Methylphenol	0/93	<400.00	<20000.00	1639.24
2-Nitrophenol	0/93	<400.00	<20000.00	1639.24
4-Nitrophenol	8/93	1260.00	3330.00	7234.73
4-Chloro-3-methylphenol	10/93	<400.00	4530.00	1888.38
Pentachlorophenol	10/93	1390.00	4580.00	8123.11
Phenol	10/93	<400.00	3660.00	1944.19
2,4,5-Trichlorophenol	0/93	<2000.00	<90000.00	8091.39
2,4,6-Trichlorophenol	0/93	<400.00	<20000.00	1639.24
Biphenyls	0/75	<10.00	20000.00	1774.80
Dibenzothiophene	0/75	<0.50	20000.00	1773.72
Dimethylanaline	0/75	<300.00	20000.00	1784.00
Methylphenanthrenes	0/75	<1.40	20000.00	1609.28
1 methyl (2-methylethyl) benzine	0/75	<300.00	20000.00	1784.00

Table F-2. Summary of Surficial Soils Constituent Concentrations (Metals) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Antimony (T)	68/103	< 13.00	3350.00	112.69
Arsenic (T)	124/124	11.00	262250.00	6404.68
Arsenic (EPTox)	95/95	<0.02	610.00	19.02
Cadmium (T)	102/103	< 0.25	498.00	50.57
Cadmium (EPTox)	71/95	< 0.005	1.50	0.11
Chromium (Y)	103/103	21.00	142.00	60.19
Chromium (EPTox)	3/95	<0.02	0.04	0.02
Copper (T)	103/103	41.00	341250.00	12653.58
Copper (EPTox)	95/95	<0.033	217.00	17.87
Lead (T)	103/103	12.00	22600.00	3101.77
Lead (EPTox)	77/95	<0.02	1.60	0.12
Mercury (T)	103/103	3.00	695000.00	57279.73
Mercury (EPTox)	94/95	<0.50	3.60	0.63
Nickel	17/103	15.00	575.00	80.81
Selenium (T)	76/76	9.00	274.00	63.88
Selenium (EPTox)	10/95	<0.083	8.30	0.30
Silver (T)	76/76	1.30	2075.00	71.74
Silver (EPTox)	0/95	<.008	<.008	<.008
Thallium (T)	7/76	< 13.0	50.00	14.00
Zinc (T)	103/103	39.00	16500.00	1368.28
Zinc (EPTox)	95/95	<0.033	64.00	3.67
Barium (T)	76/76	70.00	1528.00	255.89
Barium (EPTox)	41/95	<0.10	1.00	0.28

Table F-3. Summary of Soil Constituent Concentrations: All Samples

	Detection	Minimum Detected Value	Maximum Detected Value	Mean of Detected Values	Mean of All Values	Upper 95% Quantile
PARAMETER	Frequency	(in_ppm)	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	20/91	13	3313	519.	127.4	220.8
Arsenic	91/91	1	24950	1205.1	1205.1	1950.1
Barium	91/91	18	2250	161.6	161.6	229.4
Cadmium	50/91	0.5	268	13.7	7.8	14.
Chromium	91/91	24	310	89.9	89.9	101.2
Copper	91/91	13	13000	1229.3	1229.3	1721.4
Lead	91/91	6	9750	934.3	934.3	1400.7
Mercury	90/91	0.02	112	3.4	3.3	6.4
Nickel	91/91	20	763	73.8	73.8	90.7
Selenium	57/91	0.25	2463	109.6		
Silver	28/91	2.8	114	15.1	6.5	9.3
Thallium	14/91	8	21	13.1	11.9	12.6
Zinc	91/91	34	27000	2710.4	2710.4	3922.3
EPTOX Arsenic	7/67	0.68	11	4.24	0.739	1.163
EPTOX Silver	0/67				0.008	
EPTOX Barium	0/67				0.5	
EPTOX Cadmium	11/67	0.005	0.292	0.053	0.021	0.03
EPTOX Chromium	0/67				0.033	
EPTOX Mercury (in ppb)	1/67	1.6	1.6	1.6	0.516	0.549
EPTOX Lead	25/67	0.02	0.47	0.059	0.035	0.051
EPTOX Selenium	0/67				0.08	
EPTOX Copper	33/67	0.017	8.6	1.149	0.575	0.926
EPTOX Zinc	50/67	0.017	8.3	1.007	0.771	1.188

Table F-4. Summary of Slag Fill Constituent Concentrations

		Minimum	Maximum	Mean of	Mean of	Upper 95%
	Detection	Detected Value	Detected Value	Detected Values	All Values	Quantile
<u>Parameter</u>	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	10/18	25	3313	763.3	554.9	1005.7
Arsenic	18/18	53	24950	4837.1	4837.1	8077.9
Barium	18/18	83	2250	583.2	583.2	865.1
Cadmium	16/18	2.5	25	11.9	10.	13.5
Chromium	18/18	75	310	160.2	160.2	197.5
Copper	18/18	1030	13000	4622.8	4622.8	6205.7
Lead	18/18	112	9750	3953.3	3953.3	5885.9
Mercury	17/18	0.02	112	8.6	8.2	21.5
Nickel	18/18	28	763	119.5	119.5	202.8
Selenium	16/18	0.4	2463	262.9	262.9	623.
Silver	17/18	5	114	19.	18.2	31.
Thallium	8/18	16	21	17.4	15.2	16.4
Zinc	18/18	4415	27000	12586.9	12586.9	16081.
EPTOX Arsenic	3/15	1.1	7.7	3.3	0.924	1.973
EPTOX Silver	0/15				0.008	
EPTOX Barium	0/15				0.5	
EPTOX Cadmium	6/15	0.005	0.037	0.019	0.015	0.02
EPTOX Chromium	0/15				0.033	
EPTOX Mercury (in ppb)	0/15			•	0.5	0.5
EPTOX Lead	10/15	0.02	0.47	0.111	0.081	0.155
EPTOX Selenium	0/15				0.08	
EPTOX Copper	13/15	0.093	8.6	2.358	2.046	3.381
EPTOX Zinc	15/15	0.042	6.9	2.077	2.077	3.206

Table F-5. Summary of Granular Fill Constituent Concentrations

PARAMETER	Detection Frequency	Minimum Detected Value (in ppm)	Maximum Detected Value (in ppm)	Mean of Detected Values (in ppm)	Mean of All Values (in ppm)	Upper 95% Quantile (in ppm)
Antimony	4/20	40	213	106.	36.4	58.4
Arsenic	20/20	16	11000	1043.3	1043.3	2212.2
Barium	20/20	26	209	70.8	70.8	89.8
Cadmium	18/20	0.5	268	25.7	23.2	52.1
Chromium	20/20	44	158	82.5	82.5	97.7
Copper	20/20	28	5750	1175.7	1175.7	1961.8
Lead	20/20	19	6050	579.6	579.6	1222.6
Mercury	20/20	0.125	60	6.9	6.9	15.3
Nickel	20/20	34	151	70.	70.	83.3
Selenium	15/20	0.3	40	12.6	9.7	15.6
Silver	8/20	3.5	24	12.2	6.4	9.7
Thallium	1/20	8	8	8.	10.4	12.1
Zinc	20/20	59	2500	691.4	691.4	1072.5
EPTOX Arsenic	4/13	0.68	11	4.945	1.75	3.735
EPTOX Silver	0/13				0.008	
EPTOX Barium	0/13				0.5	
EPTOX Cadmium	3/13	0.043	0.292	0.146	0.043	0.091
EPTOX Chromium	0/13				0.033	
EPTOX Mercury (in ppb)	1/13	1.6	1.6	1.6	0.585	0.769
EPTOX Lead	8/13	0.022	0.05	0.033	0.024	0.029
EPTOX Selenium	0/13				0.08	
EPTOX Copper	8/13	0.033	3.3	0.856	0.533	1.124
EPTOX Zinc	11/13	0.023	8.3	1.535	1.301	2.898

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Table F-6. Summary of Native Soil Constituent Concentrations

	Detection	Minimum Detected Value	Maximum Detected Value	Mean of Detected Values	Mean of All Values	Upper 95% Quantile
PARAMETER	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)	(in ppm)
	6.450	10	0.5	17.0	16.5	1.0
Antimony	6/53	13	25	17.8	16.5	18.
Arsenic	53/53	1	325	32.6	32.6	51.9
Barium	53/53	18	108	52.8	52.8	59.5
Cadmium	16/53	0.58	12	2.8	1.2	1.8
Chromium	53/53	24	132	68.8	68.8	76.2
Copper	53/53	13	805	97.1	97.1	138.4
Lead	53/53	6	435	42.8	42.8	66.6
Mercury	53/53	0.03	8	0.4	0.4	0.7
Nickel	53/53	20	187	59.7	59.7	68.1
Selenium	24/53	0.25	505	53.1	25.6	50.5
Silver	3/53	2.8	7	4.4	2.6	2.8
Thallium	5/53	8	8	8.	11.3	12.2
Zinc	53/53	34	1200	118.	118.	170.4
EPTOX Arsenic	0/39				0.33	
EPTOX Silver	0/39				0.008	
EPTOX Barium	0/39				0.5	
EPTOX Cadmium	2/39	0.01	0.042	0.026	0.016	0.019
EPTOX Chromium	0/39				0.033	
EPTOX Mercury (in ppb)	0/39				0.5	0.5
EPTOX Lead	8/39	0.02	0.03	0.021	0.02	0.021
EPTOX Selenium	0/39			,	0.08	
EPTOX Copper	12/39	0.017	0.084	0.036	0.023	0.028
EPTOX Zinc	24/39	0.017	2	0.138	0.091	0.196

Table F-7. Summary of Slag Fill Constituent Concentrations: Soils Collected at 0 - 10 ft. Depth Interval

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		Minimum	Maximum	Mean of	Mean of
	Detection	Detected Value	Detected Value	Detected Values	All Values
PARAMETER	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	6/8	228	3313	1411.2	1061.6
Arsenic	8/8	53	24950	8078.5	8078.5
Barium	8/8	100	700	392.3	392.3
Cadmium	7/8	6.8	25	15.	13.2
Chromium	8/8	75	310	172.	172.
Copper	8/8	1850	13000	6546.9	6546.9
Lead	8/8	198	9750	5496.6	5496.6
Mercury	8/8	0.02	112	18.22	18.22
Nickel	8/8	45	223	102.1	102.1
Selenium	7/8	1	2013	267.6	267.6
Silver	8/8	5.3	114	31.2	31.2
Thallium	3/8	16	17	16.3	14.3
Zinc	8/8	6000	27000	14875.	14875.
EPTOX Arsenic	1/8	7.7	7.7	7.7	1.251
EPTOX Silver	0/8				0.008
EPTOX Barium	0/8				0.5
EPTOX Cadmium	6/8	0.005	0.037	0.019	0.016
EPTOX Chromium	0/8				0.033
EPTOX Mercury (in ppb)	0/8				0.5
EPTOX Lead	5/8	0.02	. 0.47	0.164	0.11
EPTOX Selenium	0/8				0.08
EPTOX Copper	8/8	0.093	8.6	2.989	2.989
EPTOX Zinc	8/8	0.042	5.8	1.884	1.884
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Table F-8. Summary of Slag Fill Constituent Concentrations: Soils Collected at 10 - 25 ft. Depth Interval

		Minimum	Maximum	Mean of	Mean of
	Detection	Detected Value	Detected Value	Detected Values	All Values
<u>PARAMETER</u>	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	3/9	25	688	183.5	126.7
Arsenic	9/9	100	7000	2090.6	2090.6
Barium	9/9	83	2250	770.4	770.4
Cadmium	8/9	2.5	13	8.4	6.7
Chromium	9/9	103	300	156.1	156.1
Copper	9/9	1030	4925	3101.1	3101.1
Lead	9/9	112	8950	2331.8	2331.8
Mercury	9/9	0.02	0.4	0.11	0.11
Nickel	9/9	28	120	63.4	63.4
Selenium	8/9	0.4	2463	285.2	285.2
Silver	8/9	5	11	7.5	7.2
Thallium	5/9	17	21	18.	16.2
Zinc	9/9	4415	19250	9660.	9660.
EPTOX Arsenic	2/5	1.1	1.1	1.1	0.638
EPTOX Silver	0/5				0.008
EPTOX Barium	0/5				0.5
EPTOX Cadmium	0/5				0.014
EPTOX Chromium	0/5				0.033
EPTOX Mercury (in ppb)	0/5			• • • •	0.5
EPTOX Lead	3/5	0.02	0.2	0.08	0.056
EPTOX Selenium	0/5				0.08
EPTOX Copper	4/5	0.105	2	0.861	0.692
EPTOX Zinc	5/5	0.5	6.9	2.78	2.78

Table F-9. Summary of Slag Fill Constituent Concentrations: Soils Collected at 25+ Depth Interval

		Minimum	Maximum	Mean of	Mean of
	Detection	Detected Value	Detected Value	Detected Values	All Values
PARAMETER	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	1/1	355	355	355.	355.
Arsenic	1/1	3625	3625	3625.	3625.
Barium	1/1	425	425	425.	425.
Cadmium	1/1	14	14	14.	14.
Chromium	1/1	103	103	103.	103.
Copper	1/1	2925	2925	2925.	2925.
Lead	1/1	6200	6200	6200.	6200.
Mercury	0/1				0.03
Nickel	1/1	763	763	763.	763.
Selenium	1/1	25	25	25.	25.
Silver	1/1	13	13	13.	13.
Thallium	0/1				13.
Zinc	1/1	20625	20625	20625.	20625.
EPTOX Arsenic	0/2				0.33
EPTOX Silver	0/2				0.008
EPTOX Barium	0/2				0.5
EPTOX Cadmium	0/2				0.012
EPTOX Chromium	0/2				0.033
EPTOX Mercury (in ppb)	0/2				0.5
EPTOX Lead	2/2	0.022	0.03	0.026	0.026
EPTOX Selenium	0/2				0.08
EPTOX Copper	1/2	3.3	3.3	3.3	1.658
EPTOX Zinc	2/2	0.58	1.6	1.09	1.09

Table F-10. Summary of Granular Fill Soil Constituent Concentrations: Soils Collected at 0 - 10 ft. Depth Interval

		Minimum	Maximum	Mean of	Mean of
	Detection	Detected Value	Detected Value	Detected Values	All Values
PARAMETER	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	4/13	40	213	106.	45.3
Arsenic	13/13	18	11000	1563.7	1563.7
Barium	13/13	30	209	80.3	80.3
Cadmium	12/13	1.9	268	37.7	34.9
Chromium	13/13	44	133	74.5	74.5
Copper	13/13	38	5750	1732.2	1732.2
Lead	13/13	23	6050	848.5	848.5
Mercury	13/13	0.16	60	10.5	10.5
Nickel	13/13	34	151	75.7	75.7
Selenium	9/13	0.55	40	14.7	10.5
Silver	8/13	3.5	24	12.2	8.4
Thallium	1/13	8	8	8.	10.8
Zinc	13/13	110	2500	877.6	877.6
	·				
EPTOX Arsenic	4/9	0.68	11	4.945	2.381
EPTOX Silver	0/9				0.008
EPTOX Barium	0/9				0.5
EPTOX Cadmium	3/9	0.043	0.292	0.146	0.058
EPTOX Chromium	0/9	•			0.033
EPTOX Mercury (in ppb)	1/9	1.6	1.6	1.6	0.622
EPTOX Lead	4/9	0.02	0.05	0.031	0.025
EPTOX Selenium	0/9				0.08
EPTOX Copper	7/9	0.033	3.3	0.973	0.76
EPTOX Zinc	9,/9	0.037	8.3	1.218	1.218

Table F-11. Summary of Granular Fill Soil Constituent Concentrations: Soils Collected at 10 - 25 ft. Depth Interval

		Minimum	Maximum	Mean of	Mean of
	Detection	Detected Value	Detected Value	Detected Values	All Values
<u>PARAMETER</u>	Frequency	(in ppm)	(in ppm)	(in ppm)	(in ppm)
Antimony	0/5				20.2
Arsenic	5/5	16	188	60.6	60.6
Barium	5/5	26	93	54.4	54.4
Cadmium	4/5	0.5	2	1.4	1.2
Chromium	5/5	70	158	94.8	94.8
Copper	5/5	28	293	107.	107.
Lead	5/5	19	113	54.	54.
Mercury	5/5	0.125	0.47	0.3	0.3
Nickel	5/5	41	93	60.2	60.2
Selenium		0.3	25	11.3	11.3
Silver	5/5	0.5	23	11.5	2.5
	0/5		••••		9.5
Thallium	0/5		1676		371.6
Zinc	5/5	59	1575	371.6	3/1.0
EPTOX Arsenic	0/3			••••	0.33
EPTOX Silver	0/3				0.008
EPTOX Barium	0/3				0.5
EPTOX Cadmium	0/3				0.003
EPTOX Chromium	0/3				0.033
EPTOX Mercury (in ppb)	0/3				0.5
EPTOX Lead	3/3	0.02	0.03	0.023	0.023
EPTOX Selenium	0/3	3.02			0.08
EPTOX Copper	1/3	0.038	0.038	0.038	0.024
EPTOX Zinc	2/3	0.023	5.9	2.962	1.98

Table F-12. Summary of Granular Fill Soil Constituent Concentrations: Soils Collected at 25+ ft. Depth Interval

	Datastis	Minimum Detected Value	Maximum Detected Value	Mean of Detected Values	Mean of All Values
DADAMETER	Detection			(in ppm)	(in ppm)
PARAMETER	Frequency	(in ppm)	(in ppm)	(III phill)	(Tri bbiii)
Antimony	0/2				19.
Arsenic	2/2	75	160	117.5	117.5
Barium	2/2	46	53	49.5	49.5
Cadmium	2/2	1.5	3.3	2.4	2.4
Chromium	2/2	68	138	103.	103.
Copper	2/2	158	301	229.5	229.5
Lead	2/2	100	191	145.5	145.5
Mercury	2/2	0.25	0.29	0.3	0.3
Nickel	2/2	55	60	57.5	57.5
Selenium	' 1/2	0.75	0.75	0.8	0.9
Silver	0/2				2.5
Thallium	0/2				9.
Zinc	2/2	140	421	280.2	280.5
EPTOX Arsenic	0/1				0.33
EPTOX Silver	0/1				0.008
EPTOX Barium	0/1				0.5
EPTOX Cadmium	0/1	• • • •			0.02
EPTOX Chromium	0/1				0.033
EPTOX Mercury (in ppb)	0/1				0.52
EPTOX Lead	0/1			••••	0.02
EPTOX Selenium	0/1				0.08
EPTOX Copper	0/1		,		0.017
EPTOX Zinc	0/1				0.017

Table F-13. Summary of Groundwater Constituent Concentrations

!				Mean of	Upper 95%
	Detection	Minimum	Maximum	All Values	Quantile
PARAMETER	Frequency	Value (in ppb)	Value (in ppb)	(in ppb)	(in ppb)
Antimony(D)	4/56	<80	310	86.3	94.8
Antimony(T)	8/56	<80	330	95.9	109.
Arsenic(D)	53/56	<6	30600	4175.5	6294.8
Arsenic(T)	54/56	<6	30600	5127.9	7353.8
Barium(D)	9/56	<110	220	115.9	1226.
Barium(T)	28/56	<110	1100	218.2	275.5
Cadmium(D)	22/56	<1	375	16.	30.
Cadmium(T)	37/56	<1	388	24.7	41.
Chromium(D)	0/56	<30		<30	<30
Chromium(T)	23/56	<30	1010	96.8	145.9
Copper(D)	44/56	<8	4740	412.3	686.
Copper(T)	53/56	<8	27400	1641.8	2732.
Nickel(D)	27/56	<30	1130	103.7	157.8
Nickel(T)	36/56	<30	3750	209.9	351.2
Selenium(D)	9/56	<5	338	32.2	51.2
Selenium(T)	13/56	<5	350	38.9	60.4
Silver(D)	0/56	<8		<8	<8
Silver(T)	2/56	<8	9	8.	8.1
Thallium(D)	7/56	<100	375	116.5	131.8
Thallium(T)	7/56	<100	400	117.3	133.5
Zinc(D)	53/56	6	27750	1335.8	2420.8
Zinc(T)	55/56	<8	32500	2090.9	3376.7
Lead(D)	1/56	<5	50	23.5	28.8
Lead(T)	33/56	<5	775	97.4	137.4
Mercury(T)	3/32	<0.5	2.9	0.6	0.8
Manganese(T)	42/42	63	8130	1857.	2468.5
Iron(T)	42/42	113	441000	74753.8	112940.9

Table F-14. Summary of Plant Area Groundwater Constituent Concentrations

1				Mean of	Upper 95%
	Detection	Minimum	Maximum	All Values	Quantile
PARAMETER	Frequency	Value (in ppb)	Value (in ppb)	(in ppb)	(in ppb)
Antimony(D)	4/44	<80	310	88.	98.9
Antimony(T)	8/44	<80	330	100.3	116.8
Arsenic(D)	42/44	<6	30600	5304.	7919.9
Arsenic(T)	42/44	<6	30600	6502.9	9210.8
Barium(D)	8/44	<110	220	117.5	126.
Barium(T)	22/44	<110	՝ 1100	230.2	301.4
Cadmium(D)	20/44	<1	375	19.5	37.4
Cadmium(T)	32/44	<1	388	30.6	51.1
Chromium(D)	0/44	<30		<30	<30
Chromium(T)	17/44	<30	1010	106.8	168.7
Copper(D)	38/44	<8	4740	519.	863.1
Copper(T)	44/44	10	27400	2054.8	3427.
Nickel(D)	27/44	<30	1130	123.8	191.9
Nickel(T)	33/44	<30	3750	249.1	428.3
Selenium(D)	8/44	<5	225	32.1	51,4
Selenium(T)	10/44	<5	225	34.7	55.5
Silver(D)	0/44	<8		<8	<8
Silver(T)	1/44	<8	9	8.	8.1
Thallium(D)	7/44	<100	375	121.	140.4
Thallium(T)	7/44	<100	400	122.1	142.6
Zinc(D)	42/44	<8	27750	1693.7	3066.3
Zinc(T)	43/44	<8	32500	2632.9	4244.
Lead(D)	1/44	<5	38		
Lead(T)	29/44	<5	775	112.9	162.
Mercury(T)	2/20	<.5	2.9	0.6	0.9
Manganese(T)	32/32	63	8130	2093.9	2848.
Iron(T)	32/32	113	441000	85307.2	133807.2

Table F-15. Summary of Stack Groundwater Constituent Concentrations

				Mean of	Upper 95%
	Detection	Minimum	Maximum	All Values	Quantile
PARAMETER	Frequency	Value (in ppb)	Value (in ppb)	(in ppb)	(in ppb)
Antimony(D)	0/8	<80	••••	<80	<80
Antimony(T)	0/8	<80		<80	<80
Arsenic(D)	8/8	20	101	51.4	72.9
Arsenic(T)	8/8	39	. 313	120.4	216.9
Barium(D)	0/8	<110		<110	<110
Barium(T)	3/8	<110	220	137.5	180.1
Cadmium(D)	2/8	<1	26	4.1	11.5
Cadmium(T)	4/8	<1	26	4.1	11.5
Chromium(D)	0/8	<30		<30	<30
Chromium(T)	3/8	<30	163	46.6	85.9
Copper(D)	5/8	<8	81	25.6	46.
Copper(T)	6/8	<8	368	125.	235.2
Nickel(D)	0/8	<30		<30	<30
Nickel(T)	1/8	<30	150	45.	80.5
Selenium(D)	1/8	<5	338	46.6	145.1
Selenium(T)	2/8	<5	350	48.1	150.1
Silver(D)	0/8	<8		<8	<8
Silver(T)	1/8	<8	9	8.1	8.4
Thallium(D)	0/8	<100		<100	<100
Thallium(T)	0/8	<100		<100	<100
Zinc(D)	7/8	<6	116	28.2	58.9
Zinc(T)	8/8	10	188	65.9	117.1
Lead(D)	0/8	<5	<25		
Lead(T)	3/8	<5	263	46.4	120.3
Mercury(T)	1/8	<.5	1.8	0.7	1.
Manganese(T)	7/7	175	3530	914.7	2036.4
Iron(T)	7/7	450	66300	13832.9	35565.

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Table F-16. Summary of Parking Lot Groundwater Constituent Concentrations

PARAMETER	Detection Frequency	Minimum Value (in ppb)	Maximum Value (in ppb)	Mean of All Values (in ppb)	Upper 95% Quantile (in ppb)
Antimony(D)	0/4	<80	<80	<80	<80
Antimony(T)	0/4	<80	••••	<80	<80
Arsenic(D)	3/4	<6	10	8.2	11.
Arsenic(T)	4/4	9	29	18.2	34.5
Barium(D)	1/4	<110	110	110.	110.
Barium(T)	3/4	<110	440	247.5	510.1
Cadmium(D)	0/4	<1		<1	<1
Cadmium(T)	1/4	<1	1	1.	1.
Chromium(D)	0/4	<30		<30	<30
Chromium(T)	3/4	<30	238	86.5	247.4
Copper(D)	1/4	<8	26	12.5	26.8
Copper(T)	3/4	<8	291	132.2	352.4
Nickel(D)	0/4	<30		<30	<30
Nickel(T)	2/4	<30	212	108.8	256.9
Selenium(D)	0/4	<5	•••-	<5	<5
Selenium(T)	1/4	<5	250	66.2	261.2
Silver(D)	0/4	<8>		<8	<8
Silver(T)	0/4	<8		<8	<8
Thallium(D)	0/4	<100		<100	<100
Thallium(T)	0/4	<100		<100	<100
Zinc(D)	4/4	9	19	14.2	22.2
Zinc(T)	4/4	56	338	179.2	398.
Lead(D)	0/4	<5		<5	<5
Lead(T)	1/4	<5	50	29.5	60.1
Mercury(T)	0/4	<.5	••••	<.5	<.5
Manganese(T)	3/3	213	3240	1537.6	5384.2
Iron(T)	3/3	8000	204000	104333.	347884.

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Table F-17. Summary of Marine Coring Constituent Concentrations (Base Neutrals).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
	0./27	4 400 00	430000 00	1207 20
Acenaphthene	0/37	< 400.00	<30000.00	1297.29
Acenaphthylene	0/37	< 400.00	<30000.00	1297.29
Aniline	0/33	< 400.00	<30000.00	403.03
Anthracene	1/37	< 400.00	870.00	1301.89
Benzidine	0/33	3000.000	<30000.00	3030.30
Benzo(a) anthracene	5/37	< 400.00	1740.00	1376.48
Benzo(a) pyrene	5/37	< 400.00	1460.00	1367.83
Benzo(b)flouranthene	6/37	< 400.00	6300.00	1582.16
Benzo(g,h,i)perylene	3/37	< 400.00	1590.00	1328.10
Benze(k)fluoranthene	0/37	< 400.00	<30000.00	1297.29
Benzyl Alcohol	0/37	< 400.00	<30000.00	1297.29
bis(2-chloroethoxy)methane	0/37	< 400.00	<30000.00	1297.29
bis(2-chloroehtyl)ether	0/37	< 400.00	<30000.00	1297.29
bis(2-chloroisopropyl)ehter	0/37	< 400.00	<30000.00	1297.29
bis(2-ethylhexyl)phthalate	3/37	< 400.00	7200.00	1477.56
4-Bromophenyl-phenyl ether	0/37	< 400.00	<30000.00	1297.29
Butyl benzyl phthalate	1/37	< 400.00	2500.00	1337.83
4-Chloroaniline	0/37	< 400.00	<30000.00	1297.29
2-Chloronaphthalene	0/37	< 400.00	<30000.00	1297.29
4-Chlorophenyl phenyl ether	0/37	< 400.00	<30000.00	1297.29
Chrysene	6/37	< 400.00	5300.00	1524.05
Dibenzo(a,h)anthracene	0/37	< 400.00	<30000.00	1297.29
Dibenzofuran	0/37	< 400.00	<30000.00	1297.29
1,2-Dichlorobenzene	0/37	< 400.00	<30000.00	1297.29
1,3-Dichlorobenzene	0/37	< 400.00	<30000.00	1297.29
1,4-Dichlorobenzene	0/37	< 400.00	<30000.00	1297.29
3,3-Dichlorobenzidine	0/37	700.000	60000.00	2594.59
Diethyl phthalate	0/37		<30000.00	1297.29

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Table F-17. Summary of Marine Coring Constituent Concentrations (Base Neutrals) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Dimethyl phthalate	0/37	< 400.00	<30000.00	1297.29
Di-n-Butyl phthalate	0/37	< 400.00	<30000.00	1297.29
2,4-Dinitrotoluene	0/37	< 400.00	<30000.00	1297.29
2,6-Dinitrotoluene	0/37	< 400.00	<30000.00	1297.29
Di-n-Octyl phthalate	0/37	< 400.00	<30000.00	1297.29
Fluoranthene	8/37	< 400.00	36000.00	1896.21
Fluorene	0/37	< 400.00	<30000.00	1297.29
Hexachlorobenzene	0/37	< 400.00	<30000.00	1297.29
Hexachlorobutadiene	0/37	< 400.00	<30000.00	1297.29
Hexachlorocyclopentadiene	0/37	< 400.00	<30000.00	1297.29
Hexachloroethane	0/37	< 400.00	<30000.00	1297.29
Indeno(1,2,3-cd)Pyrene	3/37	< 400.00	670.00	1304.05
Isophorone	0/37	< 400.00	<30000.00	1297.29
2-Methylnaphthalene	3/37	< 400.00	4200.00	1453.78
Naphthalene	1/37	< 400.00	660.00	1304.32
2-Nitroanaline	0/37	2000.000	<200000.00	8054.05
3-Nitroanaline	0/37	2000.000	<200000.00	8054.05
4-Nitroanaline	0/37	2000.000	<200000.00	8054.05
Nitrobenzene	0/37	< 400.00	<30000.00	1297.29
N-Nitrosodimethylamine	0/37	< 400.00	500.00	403.03
N-Nitrosodipropylamine	0/37	< 400.00	<30000.00	1297.29
N-Nitrosodiphenylamine(1)	0/37	< 400.00	<30000.00	1297.29
Phenanthrene	6/37	< 400.00	36000.00	1746.21
Pyrene	6/37	< 400.00	7600.00	1805.94
1,2,4-Trichlorobenzene	0/37	< 400.00	<30000.00	1297.29
2-methyl-4,6-dinitrophenol	0/37	2000.000	<200000.00	8054.05

Table F-17. Summary of Marine Sediment Coring Constituent Concentrations (Acids) (con't).

	Detection	Minimum Value	Maximum Value	Mean of
PARAMETER	Frequency	(ppm)	(ppm)	(ppm)
		\ <u>\</u>	VE E ST	<u> </u>
Benzoic Acid	2/37	<2000.00	3500.00	8124.32
2-Chlorophenol	0/37	<400.00	<20000.00	1297.29
2,4-Dichlorophenol	0/37	<400.00	<20000.00	1297.29
2,4-Dimethylphenol	0/37	<400.00	<20000.00	1297.29
2,4-Dinitrophenol	0/37	<2000.00	<90000.00	3459.45
2-Methylphenol	0/37	<400.00	<20000.00	1297.29
4-Methylphenol	1/37	<400.00	510.00	1300.27
2-Nitrophenol	0/37	<400.00	<20000.00	1297.29
4-Nitrophenol	0/37	<2000.00	<90000.00	8054.05
4-Chloro-3-methylphenol	0/37	<400.00	<20000.00	1297.29
Pentachlorophenol	0/37	<2000.00	<90000.00	7513.51
Phenol.	0/37	<400.00	<20000.00	1297.29
2,4,5-Trichlorophenol	0/37	<2000.00	<90000.00	8054.05
2,4,6-Trichlorophenol	0/37	<400.00	<20000.00	1297.29

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Table F-17. Summary of Marine Coring Constituent Concentrations ( Metals) (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Arsenic (T)	39/39	8.50	8775.000	1712.602
Arsenic (EPTox)	37/39	< 0.007	0.610	0.124
Cadmium (EPTox)	10/39	< 0.003	0.025	0.006
Copper (T)	39/39	18.00	16300.000	1936.897
Copper (EPTox)	14/39	<.017	0.640	0.067
Chromium (EPTox)	0/39	<0.033	<0.033	<0.033
Lead (T)	39/39	11.00	4775.000	1185.128
Lead (EPTox)	30/39	< 0.033	0.630	0.098
Mercury (ppb) (EPTox)	1/39	<0.5	0.600	0.503
Selenium (EPTox)	0/39	< 0.083	< 0.083	< 0.083
Silver (EPTox)	1/39	<.008	0.011	0.008
Zinc (T)	39/39	42.00	24400.000	4677.743
Zinc (EPTox)	39/39	<0.017	6.000	1.757
Barium (EPTox)	0/39	< 0.50	< 0.500	< 0.500

Table F-18. Summary of Marine Sediment Constituent Concentrations (Base Neutrals).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
	1204401.07	(PP/	(PP)	\PP/
Acenaphthene	15/149	< 170.00	3110.00	583.22
Acenaphthylene	0/149	< 170.00	<2000.00	451.47
Aniline	0/146	< 170.00	<2000.00	444.52
Anthracene	4/149	< 170.00	1130.00	465.57
Benzidine	0/146	1000.000	<20000.00	3629.45
Benzo(a)anthracene	11/149	< 170.00	4100.00	535.30
Benzo(a)pyrene	9/149	< 170.00	1240.00	475.83
Benzo(b) flouranthene	13/149	< 170.00	2920.00	540.60
Benzo(g,h,i)perylene	0/149	< 170.00	<2000.00	457.31
Benze(k) fluoranthene	0/149	< 170.00	<2000.00	457.31
Benzyl Alcohol	0/149	< 170.00	<2000.00	451.47
bis(2-chloroethoxy)methane	0/149	< 170.00	<2000.00	451.47
bis(2-chloroehtyl)ether	0/149	< 170.00	<2000.00	451.47
bis(2-chloroisopropyl)ehter	0/149	< 170.00	<2000.00	451.47
bis(2-ethylhexyl)phthalate	7/149	< 170.00	3310.00	516.44
4-Bromophenyl-phenyl ether	0/149	< 170.00	<2000.00	457.31
Butyl benzyl phthalate	1/149	< 170.00	1080.00	461.20
4-Chloroaniline	0/149	< 170.00	<2000.00	451.47
2-Chloronaphthalene	0/149	< 170.00	<2000.00	451.47
4-Chlorophenyl phenyl ether	0/149	< 170.00	<2000.00	457.31
Chrysene	15/149	< 170.00	7190.00	611.07
Dibenzo(a,h)anthracene	0/149	< 170.00	<2000.00	457.31
Dibenzofuran	1/149	< 170.00	1900.00	459.32
1,2-Dichlorobenzene	0/149	< 170.00	<2000.00	451.47
1,3-Dichlorobenzene	1/149	< 170.00	400.00	451.94
1,4-Dichlorobenzene	14/149	< 170.00	3190.00	560.33
3,3-Dichlorobenzidine	2/149	< 330.00	800.00	905.43
Diethyl phthalate	2/149	< 170.00	3570.00	, <b>522.08</b>

Table F-18. Summary of Marine Sediment Constituent Concentrations (Base Neutrals) (con't).

	Detection	Minimum Value	Maximum Value	Mean of All Values
PARAMETER	Frequency	(ppm)	(ppm)	(ppm)
Dimethyl phthalate	0/149	< 170.00	<2000.00	451.47
Di-n-Butyl phthalate	6/149	< 170.00	770.00	465.50
2,4-Dinitrotoluene	13/149	< 170.00	2980.00	556.97
2,6-Dinitrotoluene	0/149	< 170.00	<2000.00	449.26
Di-n-Octyl phthalate	1/149	< 170.00	1220.00	462.14
Fluoranthene	21/149	< 170.00	43600.00	968.45
Fluorene	0/149	< 170.00	<2000.00	457.31
Hexachlorobenzene	0/149	< 170.00	<2000.00	457.31
Hexachlorobutadiene	0/149	< 170.00	<2000.00	451.47
Hexachlorocyclopentadiene	0/149	< 170.00	<2000.00	451.47
Hexachloroethane	0/149	< 170.00	<2000.00	451.47
Indeno(1,2,3-cd)Pyrene	1/149	< 170.00	470.00	457.78
Isophorone	0/149	< 170.00	<2000.00	451.47
2-Methylnaphthalene	0/149	< 170.00	<2000.00	451.47
Naphthalene	0/149	< 170.00	<2000.00	451.47
2-Nitroanaline	0/149	<830.00	<10000.00	2227.04
3-Nitroanaline	0/149	<830.00	<10000.00	2216.30
4-Nitroanaline	0/149	<830.00	<10000.00	2249.86
Nitrobenzene	0/149	< 170.00	<2000.00	451.47
N-Nitrosodimethylamine	0/146	< 170.00	<2000.00	444.52
N-Nitrosodipropylamine	14/149	< 170.00	3040.00	560.00
N-Nitrosodiphenylamine(1)	0/149	< 170.00	<2000.00	457.31
Phenanthrene	15/149	< 170.00	52900.00	904.49
Pyrene	31/149	< 170.00	27100.00	1018.25
1,2,4-Trichlorobenzene	14/149	< 170,00	2590.00	555.90
2-methyl-4,6-dinitrophenol	0/149	<830.00	<10000.00	2249.86
PCB's	6/36	< 200.00	12700.00	2755.55
TOC (Total Organic Carbon)	28/30	< 50.00	6900.00	2589.00

Table F-18. Summary of Marine Sediment Constituent Concentrations (Acids) (con't).

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	Detection	Minimum Value	Maximum Value	Mean of All Values
PARAMETER	Frequency	(ppm)	(ppm)	(ppm)
		1.1 4	·	
Benzoic Acid	0/148	<830.00	<10000.00	2228.58
2-Chlorophenol	14/148	<170.00	5330.00	692.09
2,4-Dichlorophenol	0/148	<170.00	<2000.00	451.14
2,4-Dimethylphenol	0/148	<170.00	<2000.00	451.14
2,4-Dinitrophenol	0/148	<830.00	<10000.00	2251.55
2-Methylphenol	0/148	<170.00	<2000.00	451.14
4-Methylphenol	1/148	<170.00	570.00	451.62
2-Nitrophenol	0/148	<170.00	<2000.00	451.14
4-Nitrophenol	13/148	<830.00	5790.00	2361.01
4-Chloro-3-methylphenol	14/148	<170.00	5640.00	728.85
Pentachlorophenol	14/148	<830.00	6800.00	2372.70
Phenol	17/148	<170.00	5140.00	852.43
2,4,5-Trichlorophenol	0/148	<830.00	<10000.00	2228.58
2,4,6-Trichlorophenol	0/148	<170.00	<2000.00	451.14

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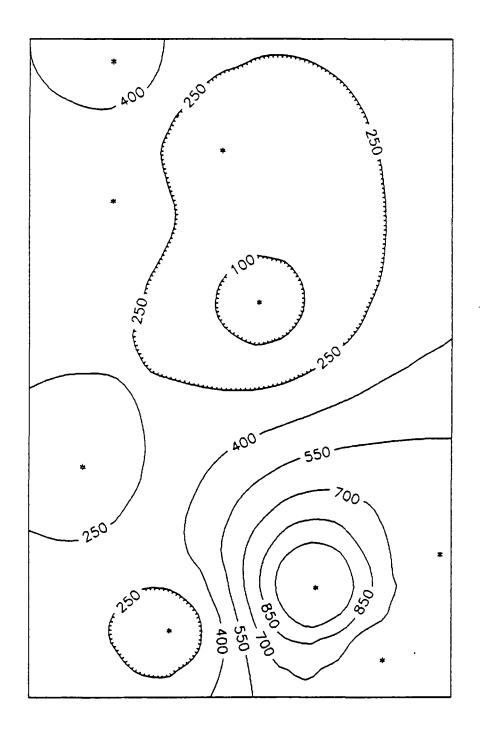
Table F-18. Summary of Marine Surface Sediment Constituent Concentrations (con't).

PARAMETER	Detection Frequency	Minimum Value (ppm)	Maximum Value (ppm)	Mean of All Values (ppm)
Arsenic (T)	150/150	< 7.00	20575.000	1891.653
• •	•			
Arsenic (EPTox)	1/28	< 0.333	0.830	0.347
Cadmium (EPTox)	4/28	< 0.003	0.025	0.006
Copper (T)	150/150	14.00	18300.000	1236.900
Chromium (EPTox)	0/28	<0.033	<0.033	<0.033
Lead (T)	150/150	13.00	9975.000	1419.580
Lead (EPTox)	9/28	< 0.02	0.520	0.042
Mercury (ppb) (T)	48/48	50.00	40000.000	2225.208
Mercury (ppb) (EPTox)	11/28	< 0.50	< 0.500	< 0.500
Selenium (EPTox)	0/28	< 0.08	< 0.08	< 0.08
Silver (EPTox)	0/28	< 0.008	< 0.008	< 0.008
Zinc (T)	150/150	28.00	21800.000	3069.666
Barium (EPTox)	0/28	< 0.50	< 0.50	< 0.50

## APPENDIX G

CONCENTRATION GRADIENT ISOPLETHS FOR SURFICIAL SOILS SAMPLES

## ADMINISTRATIVE AREA TOTAL METALS CONCENTRATION ISOPLETHS (in ppm)



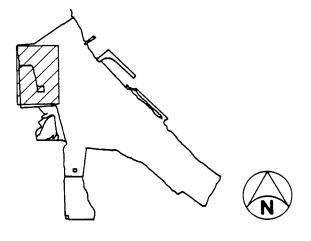
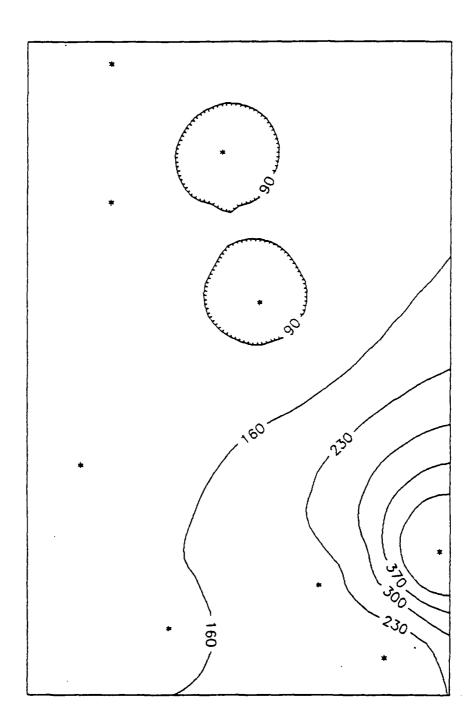


Figure G-1.
Concentration Gradient
Isopleth for Arsenic
in the Administrative Area



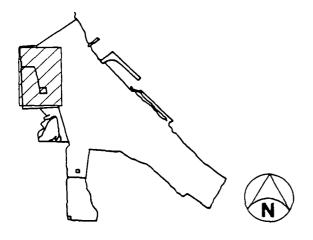
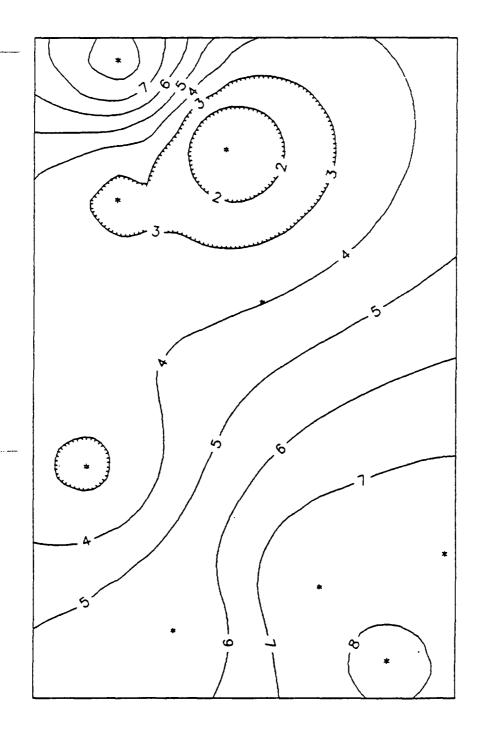


Figure G-2.
Concentration Gradient
Isopleth for Barium
in the Administrative Area



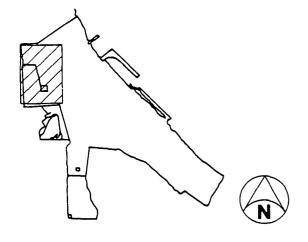
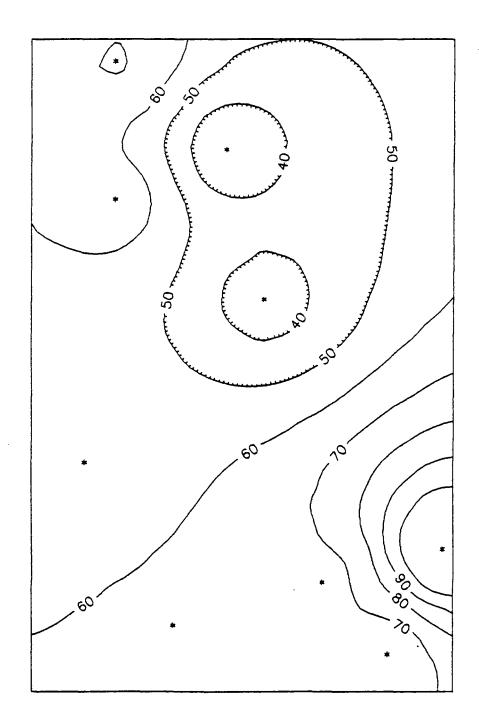


Figure G-3.
Concentration Gradient
Isopleth for Cadmium
in the Administrative Area



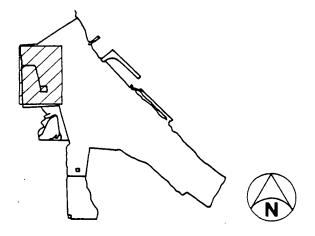
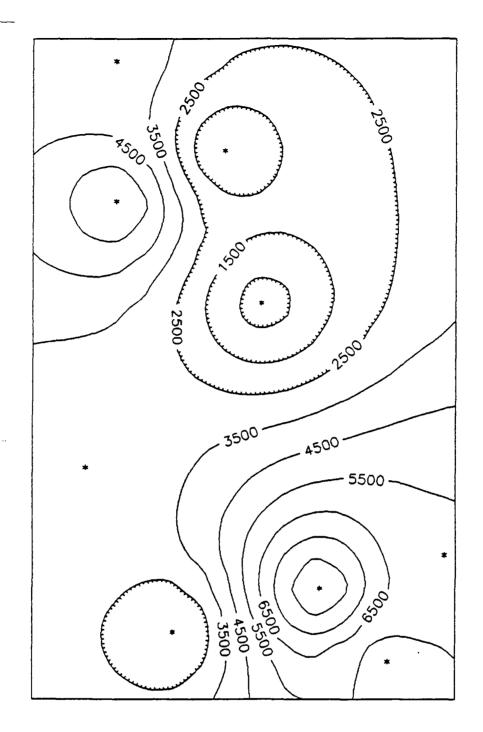


Figure G-4.
Concentration Gradient
Isopleth for Chromium
in the Administrative Area



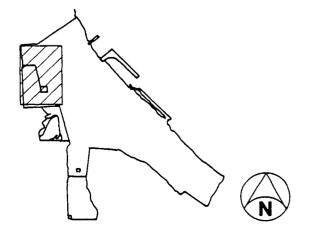
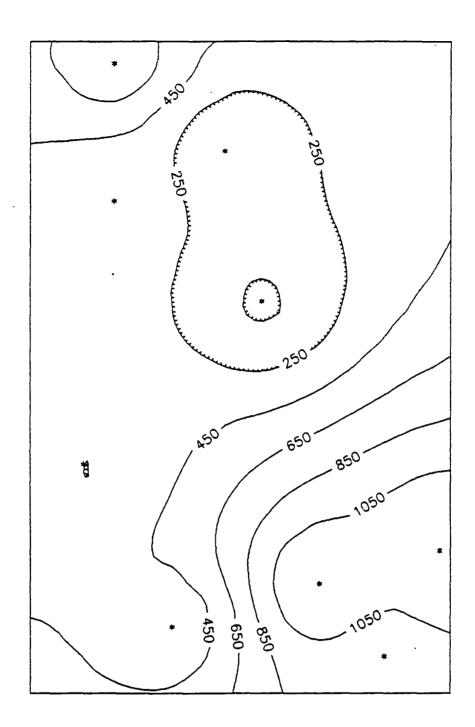


Figure G-5.
Concentration Gradient Isopleth for Copper in the Administrative Area



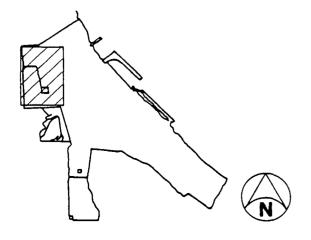
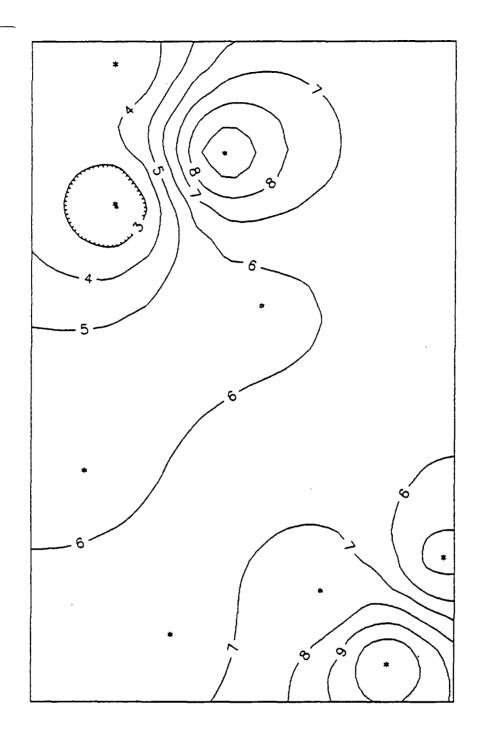


Figure G-6.
Concentration Gradient
Isopleth for Lead
in the Administrative Area



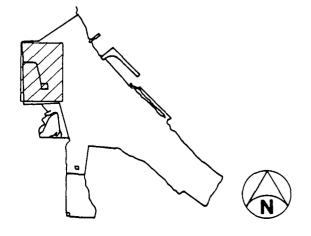
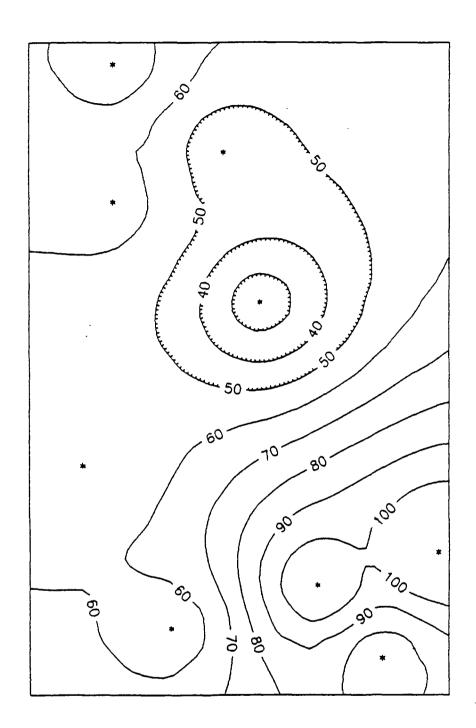


Figure G-7.
Concentration Gradient Isopleth for Mercury in the Administrative Area



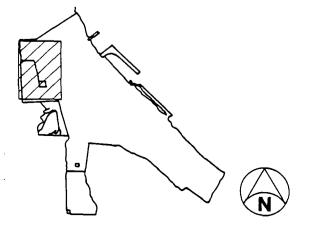
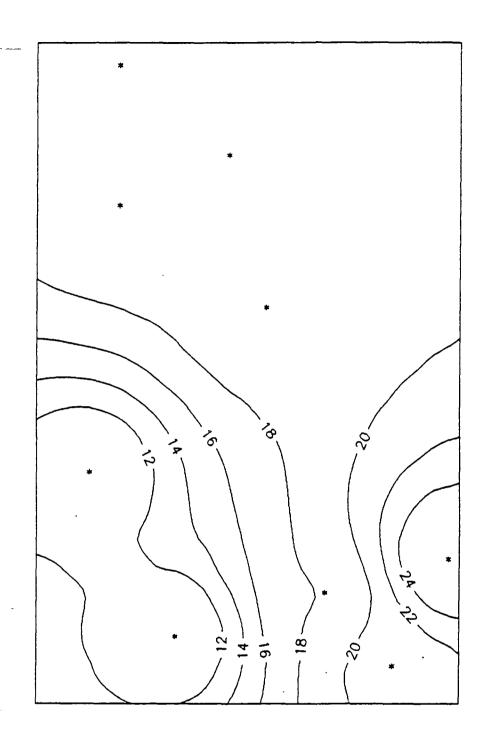


Figure G-8.
Concentration Gradient
Isopleth for Nickel
\_in the Administrative Area



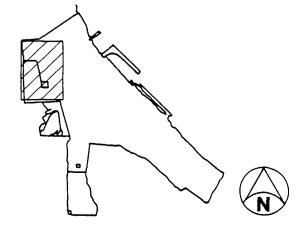
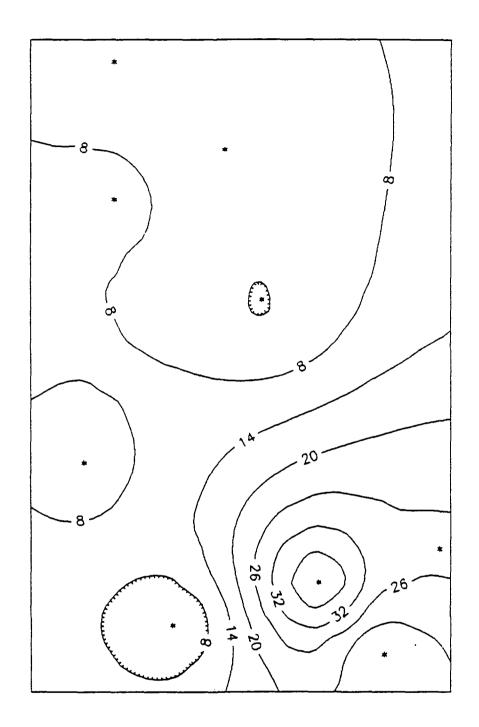


Figure G-9.
Concentration Gradient
Isopleth for Selenium
in the Administrative Area



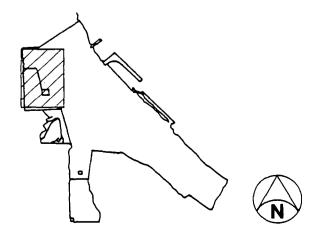
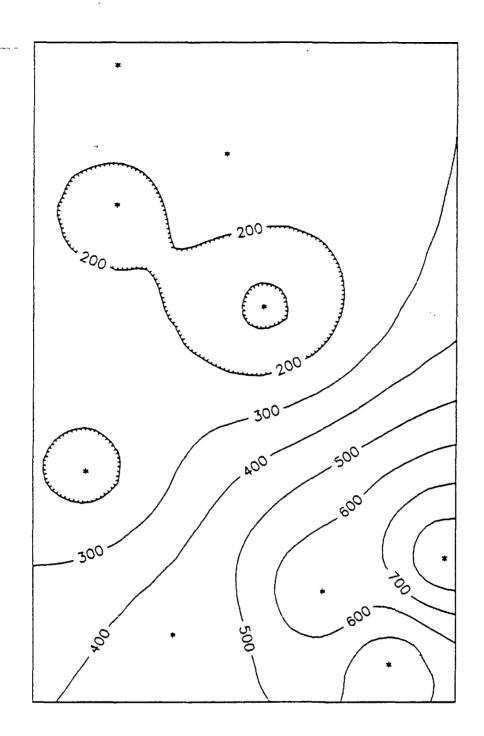


Figure G-10.
Concentration Gradient Isopleth for Silver in the Administrative Area



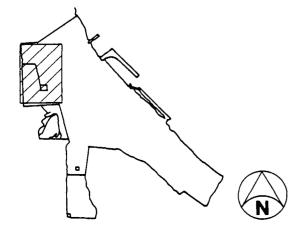


Figure G-11.
Concentration Gradient Isopleth for Zinc in the Administrative Area

## SITE STABILIZATION AND COOLING POND AREA TOTAL METALS CONCENTRATION ISOPLETHS (in ppm)



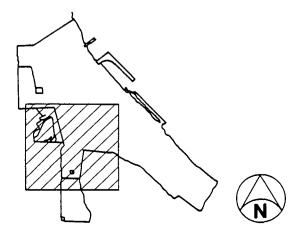
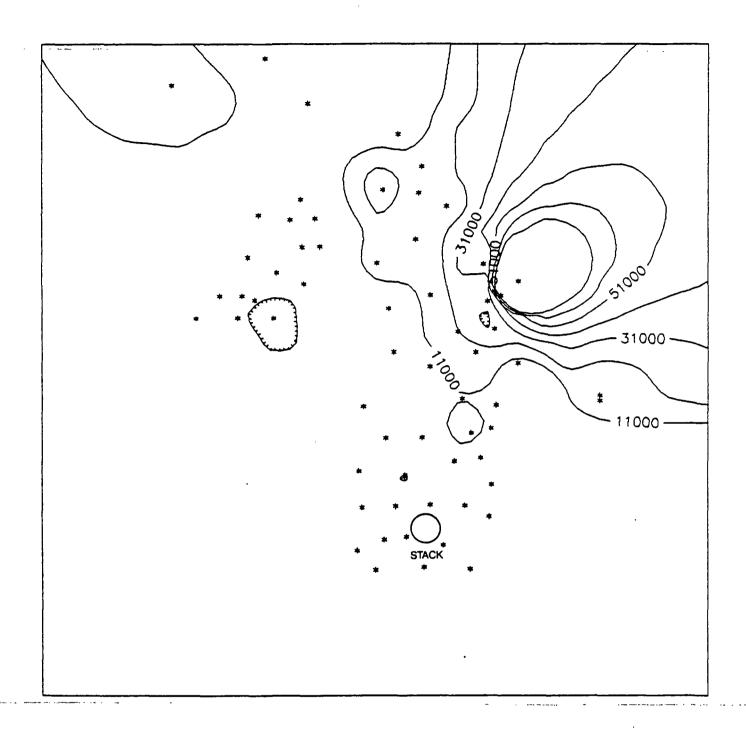


Figure G-12.
Concentration Gradient Isopleth for Antimony in the Site Stabilization and Cooling Pond Areas



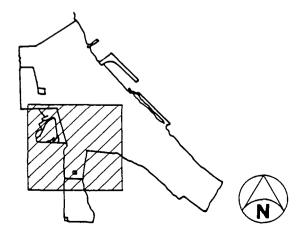


Figure G-13.
Concentration Gradient Isopleth for Arsenic in the Site Stabilization and Cooling Pond Areas



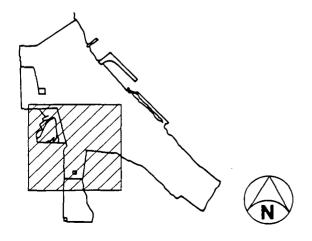


Figure G-14.
Concentration Gradient Isopleth for Barium in the Site Stabilization and Cooling Pond Areas



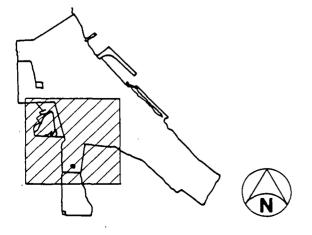
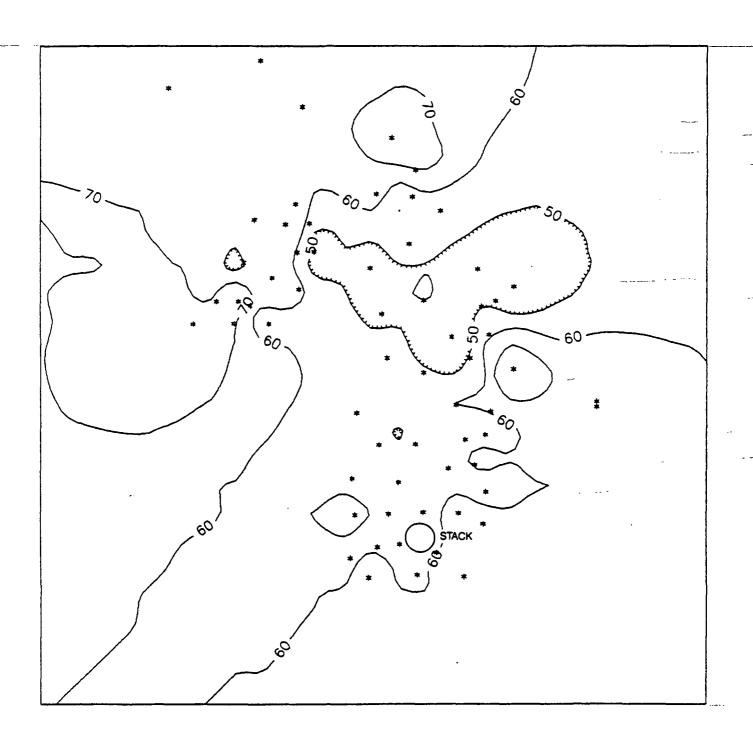


Figure G-15.
Concentration Gradient Isopleth for Cadmium in the Site Stabilization and Cooling Pond Areas



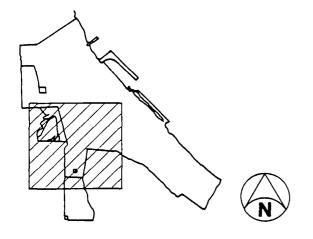
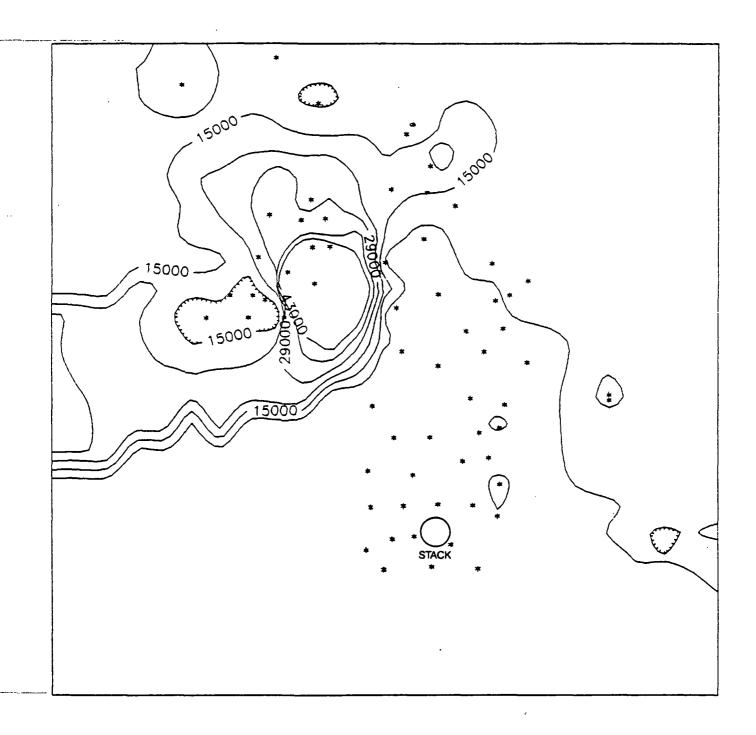


Figure G-16.
Concentration Gradient
Isopleth for Chromium
in the Site Stabilization
and Cooling Pond Areas



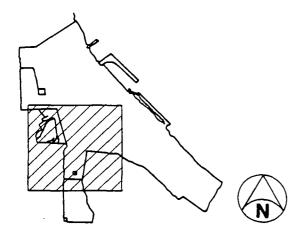
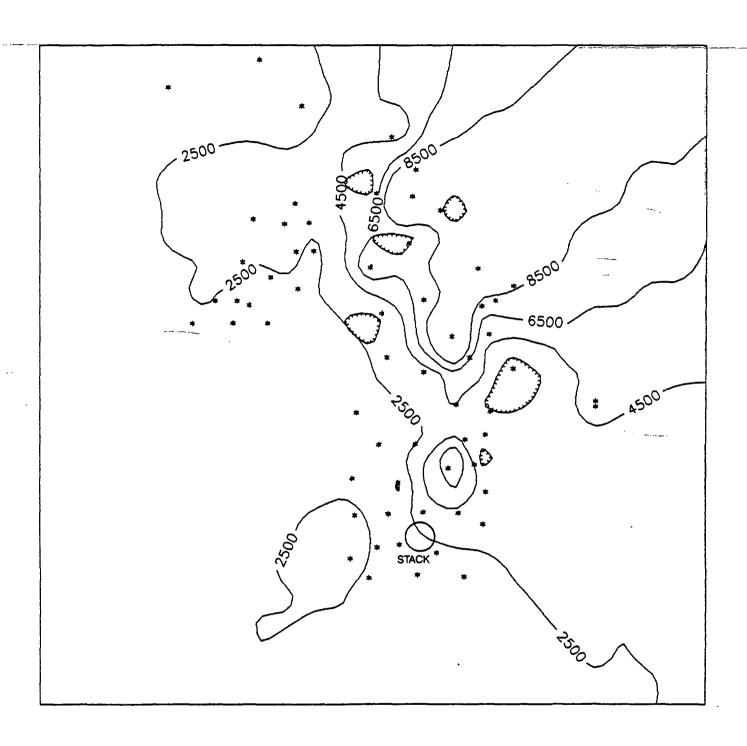


Figure G-17.
Concentration Gradient
Isopleth for Copper
in the Site Stabilization
and Cooling Pond Areas



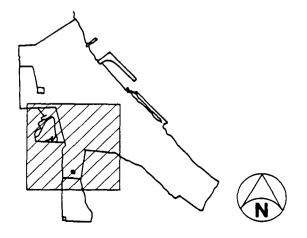
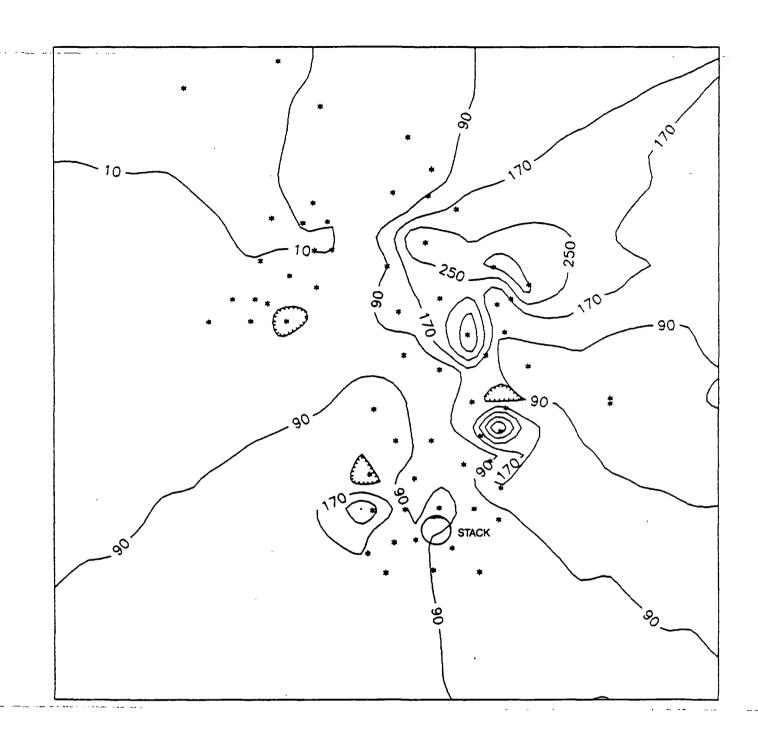


Figure G-18. Concentration Gradient
Isopleth for Lead
in the Site Stabilization
and Cooling Pond Areas



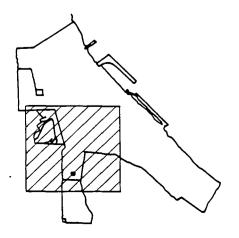
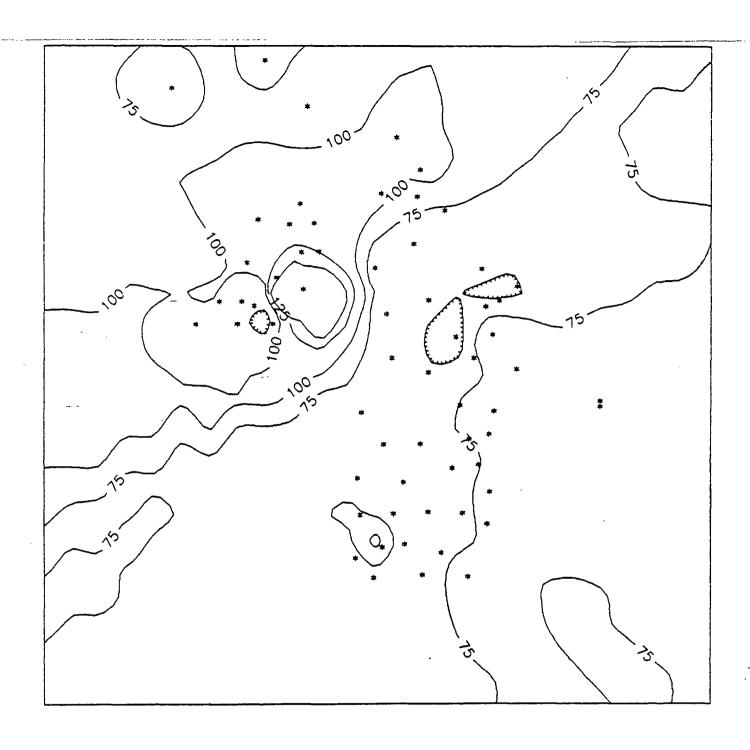


Figure G-19.
Concentration Gradient Isopleth for Mercury in the Site Stabilization and Cooling Pond Areas



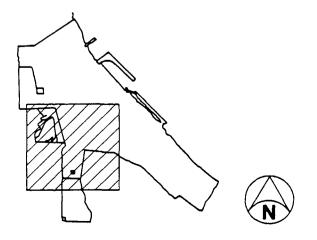
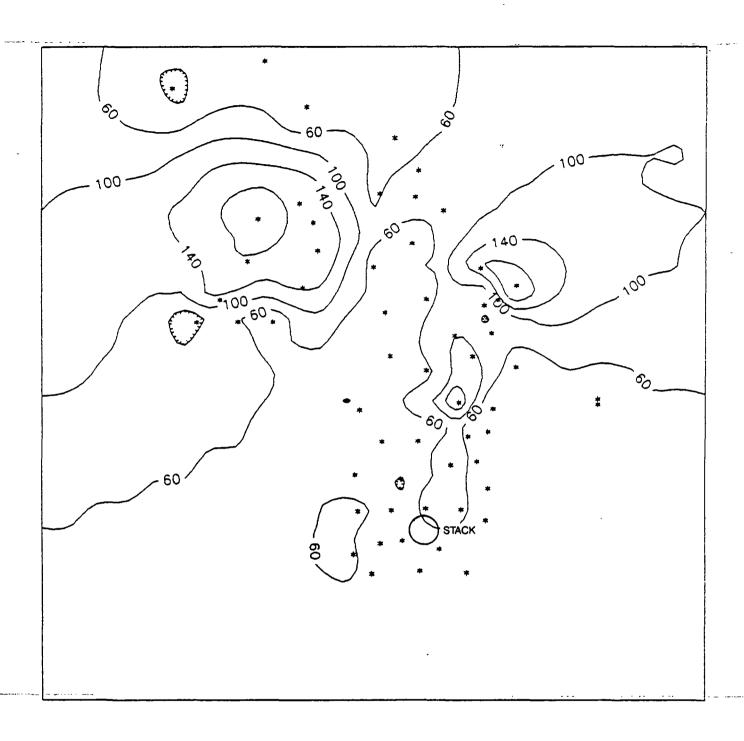


Figure G-20.
Concentration Gradient Isopleth for Nickel in the Site Stabilization and Cooling Pond Areas



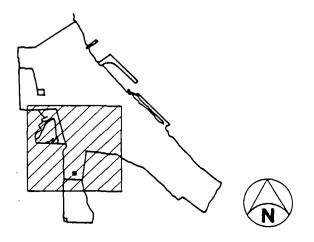
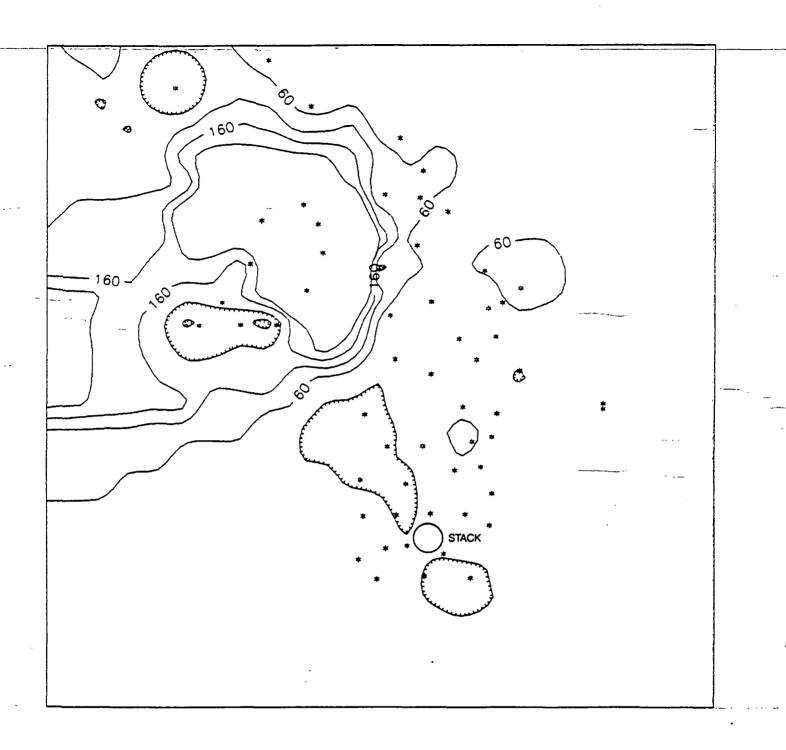


Figure G-21.
Concentration Gradient Isopleth for Selenium in the Site Stabilization and Cooling Pond Areas



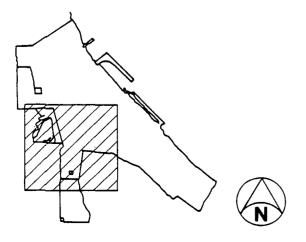


Figure G-22.
Concentration Gradient Isopleth for Silver in the Site Stabilization and Cooling Pond Areas



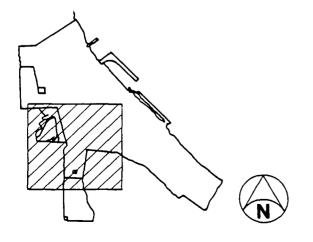
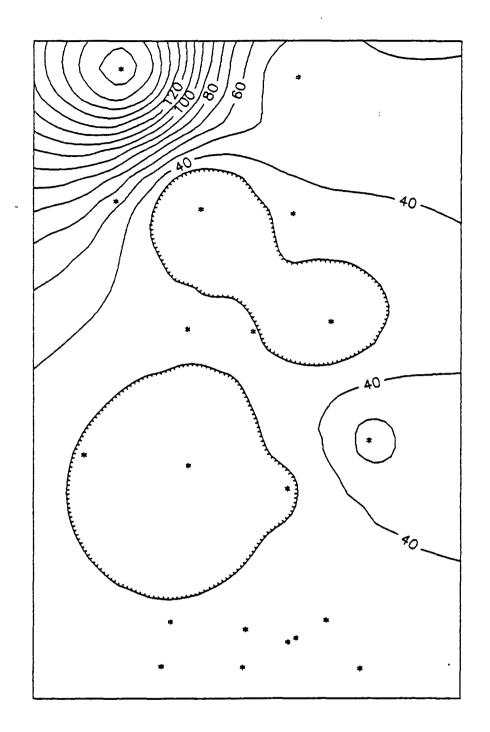


Figure G-23.
Concentration Gradient Isopleth for Zinc in the Site Stabilization and Cooling Pond Areas

## OFF-SITE AREA

TOTAL METALS CONCENTRATION ISOPLETHS (in ppm)



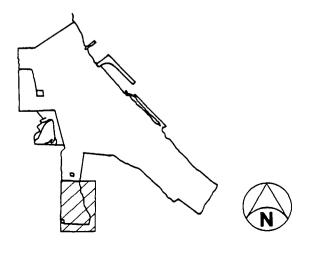
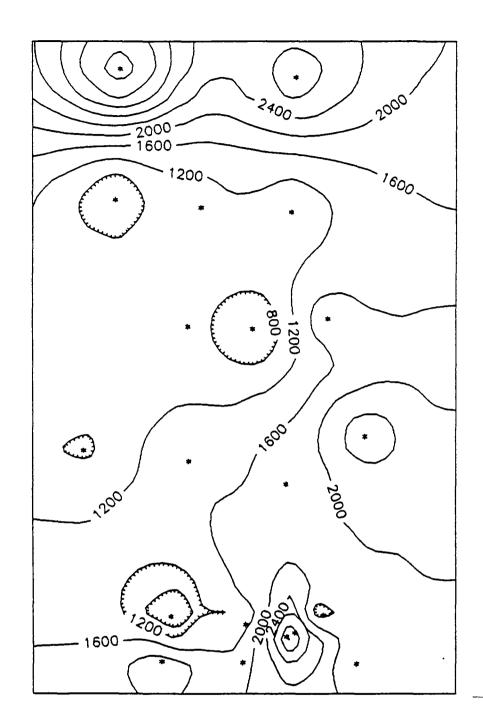


Figure G-24. Concentration Gradient Isopleth for Antimony in the Offsite Area



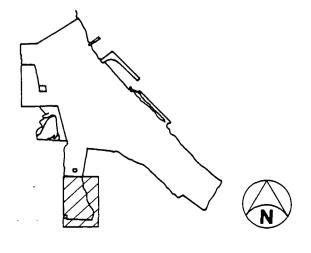
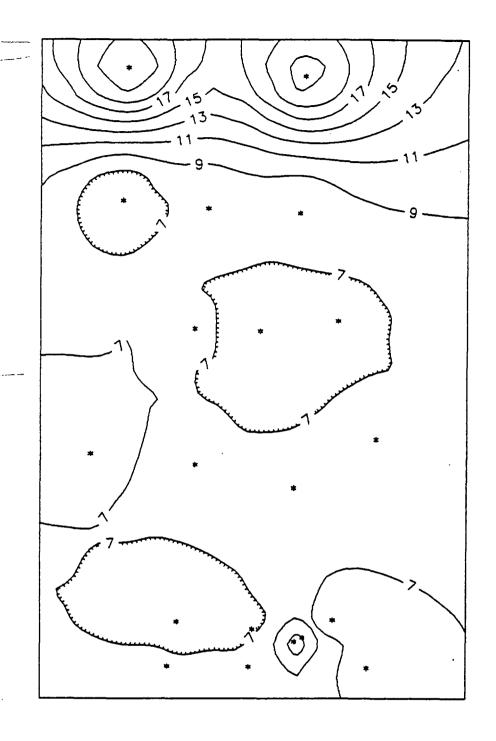


Figure G-25.
Concentration Gradient Isopleth for Arsenic in the Offsite Area



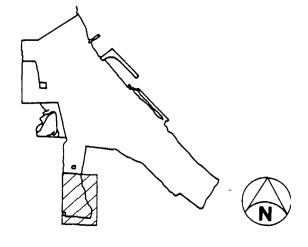
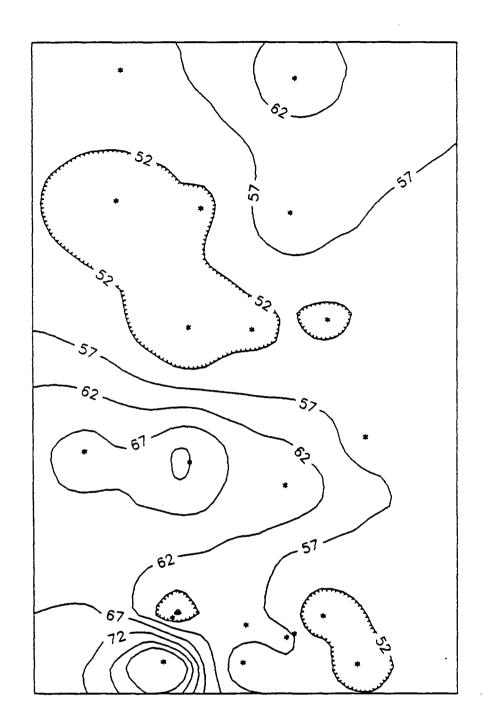


Figure G-26.
Concentration Gradient Isopleth for Cadmium in the Offsite Area



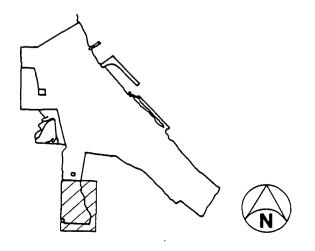
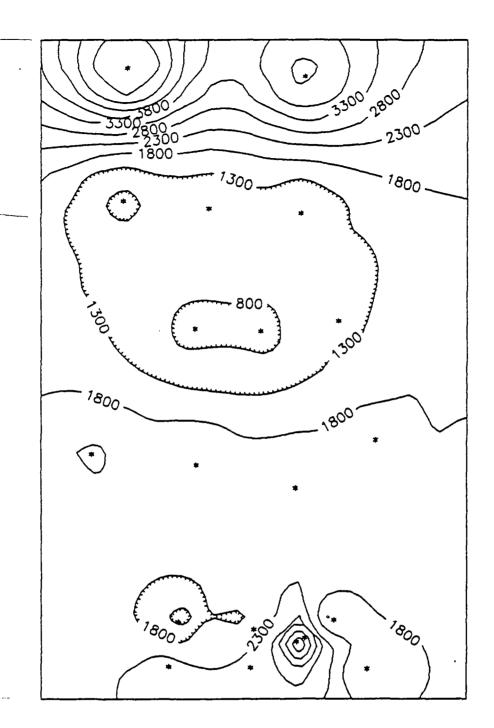


Figure G-27.
Concentration Gradient Isopleth for Chromium in the Offsite Area



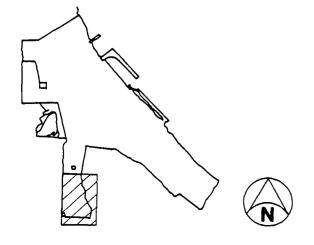
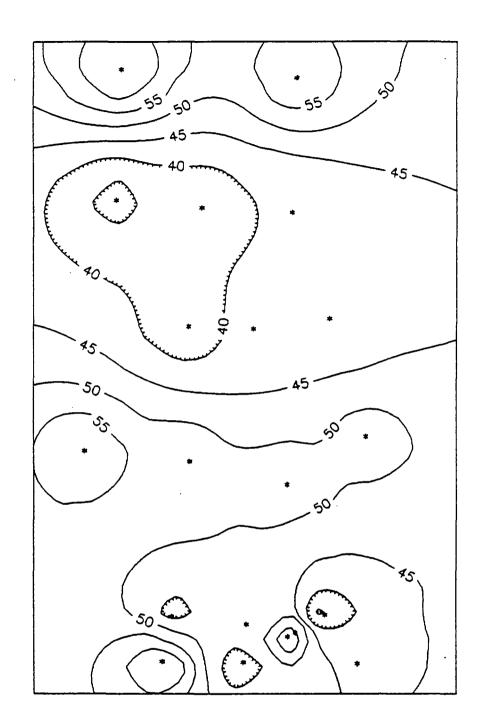


Figure G-28.
Concentration Gradient Isopleth for Copper in the Offsite Area



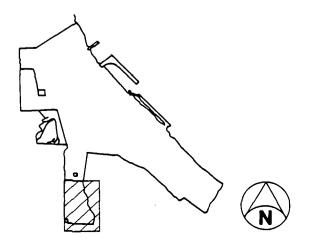
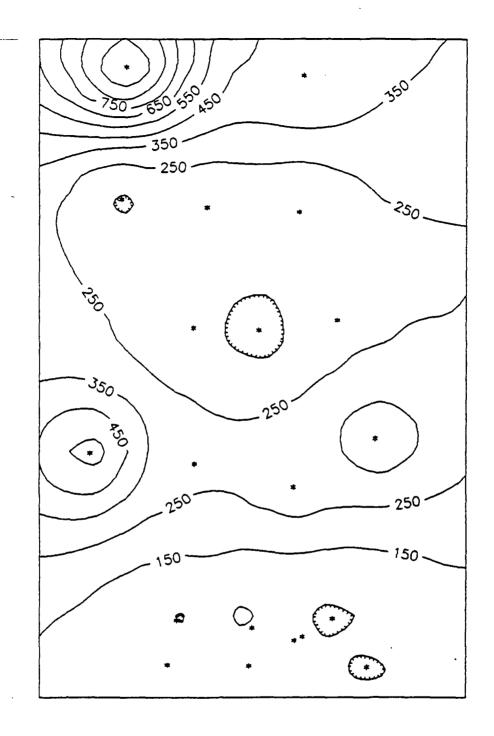


Figure G-29.
Concentration Gradient Isopleth for Nickel in the Offsite Area



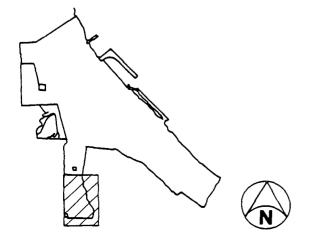
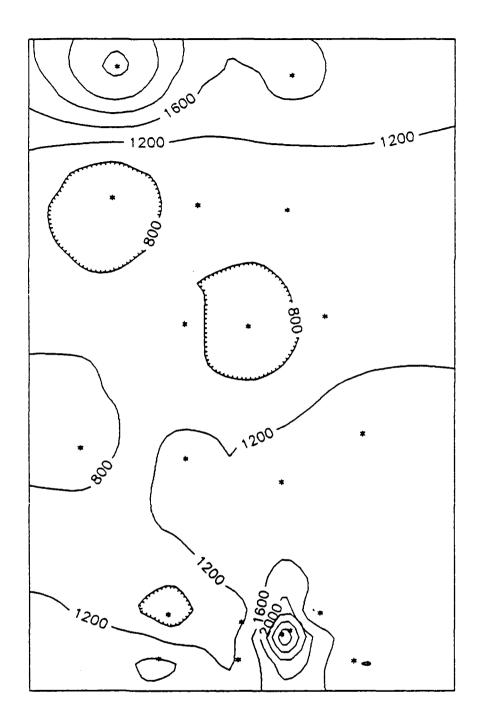


Figure G-30.
Concentration Gradient Isopleth for Zinc in the Offsite Area



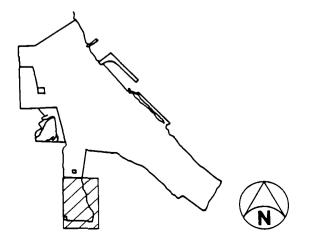


Figure G-31.
Concentration Gradient Isopleth for Lead in the Offsite Area

# Final Report

# ASARCO Tacoma Smelter Remedial Investigation

Volume 2 — Technical Data Appendices

Parametrix, Inc. in Association with Hart Crowser

#### INTRODUCTION

Based on a data validation/quality assurance review, we judged the analytical data to be generally acceptable. However, in some instances results were qualified as estimates or rejected due to violations of quality control criteria. The following codes have been used in this data package to qualify the data.

- < Less than the associated value which is the quantitation (detection) limit.
- J Indicates the compound was detected but at an estimated concentration because one or more quality control criteria were not met.
- N The compound was not detected and the associated quantitation (detection) limit is estimated because one or more quality control criteria were not met.
- R Quality control limits were grossly exceeded, making the data unusable while the compound may or may not have actually been present.
- U The compound was detected, but at a concentration of less than 5 times the level found in the method blank. Therefore the compound is considered undetected due to the excessive contamination in the blank.
- Z Dry weight results were not reported by the laboratory.
- W This qualifier is restricted to the furnace atomic absorption spectraphotometry (furnace AA) analysis of lead. It indicates the sample absorbance was less than 50 percent of the spike absorbance and the spike recovery was less than 85 percent or greater than 115 percent.
- E Indicates the Spike recovery was less than 40 percent in the furnace AA analysis of lead.
- \* The sample results are not available due to an analytical error.
- # The laboratory did not report the total organic carbon (TOC) result because the non-homogeneous nature of the sample made it difficult to get reproducible results.

Detailed discussions of the laboratory data validation are contained in the Asarco Tacoma Smelter RI/FS Data Validation Report.

## **VOLUME 2 - TECHNICAL DATA**

Appendix H - Surface Water

Appendix I - Surficial Soils

Appendix J - Subsurface Soils

Appendix K - Groundwater

Appendix L - Fill Leaching

Appendix M - Marine Surficial Sediment

Appendix N - Marine Coring

Appendix O - Bioassay

Appendix P - Benthos

APPENDIX H

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SURFACE WATER

SURFACE WATER FIELD DATA (time, flow, conductivity, pH, and temperature)

Data qualifiers:

COMP = composite sample
ND = not determined
F = field measurement of conductivity or pH

Surface water sampling, event 1 on 1/28/88

SITE	TIME	FLDW CFS	COND. UHMOS	pН	TEMP C	SITE	TIME	FLOW CFS	COND. UHMOS	pH	TEMP C
SW-1	1320	0.148	82	7.5 F	מא	SH-8	1320	<b>8.200</b>	ND	ND	ND
SW-1	1415	0.090	125	7 F	ND	5 <del>N-8</del>	1415	<b>0.</b> 697	93.3 F	7.25 F	11.1
SW-1	1520	0.060	190	6.5 F	ND	S₩-8	1527	0.000	ND	MD	ND
SW-1	1620	<b>9.</b> 259	167	ND	ND	S <del>V-</del> 8	1621	0. 290	ND	ND	:D
SW-1	1725	0.048	193	ND	ND	SH-8	1721	0.000	ND	MD	MD
SW-1	1820	<b>9.</b> 949	188	ND	ND	SN-8	1847	9. 000	ND	ND	ND
SW-1	COMP	0.088	145	6.7	ND	S₩-8	COMP	0.001	108	6.7	ND
SM-5	1330	1.180	96	7.2 F	ND	SH-9	1330	<b>0.</b> 146	89	ND	ND
SM-5	1425	0.780	115	7.5 F	ND	SH-9	1442	<b>0.</b> 255	263	'ND	ND
SW-5	1535	6.400	145	ND	ND	5₩-9	1542	<b>9. 9</b> 29	115	ND	NĐ
SM-5	1635	0.350	149	ND	ND	SH-9	1642	<b>0.0</b> 45	109	ND	ND
SW-2	1740	<b>0.</b> 28 <b>0</b>	159	ND	ND	SW-9	1742	<b>0.0</b> 33	116	GN	ND
SM-5	1830	<b>0.</b> 240	162	ND	ND.	SW-9	1850	0.037	132	ND	ND:
SN-2	COMP	<b>0.</b> 538	129	6.6	ND	SH-9	COMP	0.223	121	6.75	GM
SW-3	1335	0.620	90	7 F	ND	SW-10	1345	2.400	246	ND	ND
SH-3	1430	<b>0.</b> 420	191	7 F	ND	SW-10	1452	1.300	300	ND	ND
SW-3	1540	8.218	239	ND	ND	SH-10	1552	0.690	268	ND	ND
<del>SW-</del> 3	1540	0.150	229	ND	ND	S₩-10	1652	0.500	250	ND	ND
S₩-3	1745	0.120	245	ND	ND	S₩-10	1752	0.500	235	ND	ND
SH-3	1835	0.200	238	ND	ND	SW-10	1308	0.600	386	ND	ND
SW-3	COMP	0.287	180	7	ND	SW-10	COMP	1.015	253	6.09	۸Đ
SH-4	1340	1.500	99	7.4 F	ND	SW-11	1418	0.550	382	ND	ND
SW-4	1435	1.200	130	7 F	ND	SW-11	1505	0.200	287	ND	ND
SW-4	1545	0.670	166	ND	ND	SW-11	1605	0.070	261	ND	ND
SN-4	1645	0.600	171	ND	ND	SW-11	1705	0.030	269	ND	NĎ
SH-4	1750	0.440	183	ND	ND	5W-11	1805	0.020	285	ND	ND
S₩-4	1840	0.500	251	ND	ND	S <del>H-</del> 11	1920	0.020	295	ND	ND.
SH-4	COMP	<b>0.</b> 868	142	6.8 F	ND	SW-!1	COMP	<b>0.</b> 148	294	6.72	ND
SW-5	1345	0.132	ND	ND	ΝD	SW-12	1425	<b>0.35</b> 3	238	ND	ND
SW-5	1450	9.006	ND	ND	ND	SW-12	1525	8.173	239	ND	ND
S#-5	1545	8.001	ND	ND	ND	SW-12	1625	0.155	250	ND	ΝD
SW-5	1646	0.002	ND	ND	ND:	SW-12	1725	<b>0.</b> 155	259	ND	ND
S#-5	1735	0.00i	ND	ND	ND	SW-12	1825	<b>0.</b> 148	246	ND	ND
SW-5	1981	0.001	ND	ND	ND	SH-12	1930	0.138	277	ND	- ND
SW-5	COMP	0.024	37	7.2	ND	SH-12	COMP	<b>0.</b> 187	245	6.52	ND
54-6	1330	0.190	16	ND	ND	SW-13	1310	<b>8.</b> 310	209	מא	ND
SW-6	1435	<b>0.</b> 148	21 F	6.7 F	10	SW-13	1405	0.300	211	6.9	9
SW-6	1537	0.080	14 F	6.7 F	10.4	SW-13	1505	6.200	202	6.7	ND
SW-6	1635	0.050	18 F	6.7 F	16.1	S <del>U</del> -13	1610	9.170	205	ND	GN
SW-6	1735	0.030	30	ND	ND	S₩-13	1715	0.170	218	ND	ΦM
S <del>W-</del> 6	1855	<b>6.020</b>	37	ND	ND	SW-13	1810	0.150	225	ND	ΝD
SH-6	COMP	<b>0.085</b>	21	7.1	ND	SW-13	COMP	<b>0.</b> 217	214	6.5	ND
5₩~7	1325	0.320	114	ND	ND	SEEP-1	1630	0.00 <del>0</del>	282	5. 66	ND
SN-7	1425	0.220	111 F	9.3 F	12	SEEP-2	1640	0.000	637	6.73 F	ND
SW-7	1530	<b>e.</b> 180	69 F	7.3 F	10.6	SEEP-4	1650	0.000	635	6.63	ND
SW-7	1625	0.170	68 F	7.2 F	10.5	SEEP-5	1700	0.000	640	<b>5.</b> 43	ND
S₩-7	1730	0.090	82	מא	ФИ	SEC-A	1882	2.001	72.5 F	7.28	18.4
SH-7	1850	0.070	73	ND	ND	SEC-B	1815	0.002	132 F	5.8	23.3
SW-7	COMP	0.175	98	6.8	ND	SEC-C	1825	0.001	421 F	6.82	18.5
						SEC-D	1835	0.001	149 F	6.9	9.5

Surface water sampling, event 3 on 6/1/88.

SITE	TIME	FLOW CFS	COND. UHMOS	рН	TEMP C	SITE	TIME	FLOW CFS	COND. L <del>IHMOS</del>	Ha	TEMP C
SW-1	705	ø. ø2Ø	139	6.4 F	ND	SW-8	625	0.000	GN	ND	МD
SW-1	750	<b>0.</b> 035	186	6.4 F	12	SW-8	724	9. 333	ND	ND	ND
SW-1	845	9, 925	197	7 F	12	S <del>H-8</del>	824	9.000	ND	ND	ND
SW-1	945	<b>0.</b> 025	CN	6.5 F	13	S₩-8	924	0.000	ND	MD	ND
SW-1	1048	0.015	231	6.8 F	15.5	S₩-8	1829	9.000	ИD	ND	ND
SW-1	COMP	9. 824	ND	ND	ND	S <del>H-8</del>	COMP	8. 888	ND	ND	מא
SM-5	630	0.325	191	6.5 F	ND	SW-9	620	0.041	48	6.4	13
SW-2	730	<b>8.</b> 475	194	6.7 F	11.5	SH-9	710	0. 037	44	6.4	12.5
SM-5	830	0.525	154	6.7 F	12	SW-9	815	0.033	42	6.5	12.1
SN-S	930	0.34 <del>8</del>	168	6.7 F	13	5 <del>W-</del> 9	910	0.013	48	6.5	12.7
SM-5	1025	0.260	154	6.7 F	15	SH-9	1015	0.013	52	6.5	13.2
SM-2	COMP	<b>0.</b> 385	ND	ND	ND	S₩-9	COMP	0.027	ND	ND	ΔN
5W-3	650	0.099	295	6.4 F	ND	SH-10	630	0.930	226	6.4	12.4
SM-3	740	0.136	175	6.4 F	12	SW-10	725	1.150	197	6.7	12.2
SW-3	840	0.141	320	6.5 F	13	SW-10	825	1.260	183	6.8	12.3
SW-3	935	0.091	229	6.9 F	13.5	SW-10	920	0.880	208	5.9	12.2
5W-3	1030	0.094	193	ND	17	SW-10	1025	a. 600	243	7.1	13.2
SH-3	COMP	0.112	٧D	ND	ND	SW-10	COMP	0.964	ND	ND	ND
SW-4	625	0.580	200	6.4 F	ND	SW-11	640	0.550	ND	5.45 F	11.8
54-4	720.	0.910	237	6.6 F	12	SW-11	735	0.230	624	5.45 F	ND
SW-4	820	0.950	164	6.6 F	13	SW-11	835	0.107	390	6.8 F	ND
SW-4	925	0.680	247	6.5 F	14	SW-11	930	<b>8.</b> 115	411	7.2 F	ND
SW-4	1020	0.550	194	6.6 F	15.5	SH-11	1035	0.082	37 <del>9</del>	6.75 F	ND:
S₩-4	COMP	0.734	ND	ND	ND	SW-11	COMP	0.217	ND	ND	ND.
5W-5	645	8.824	33	6.6 F	12.8	SW-12	655	8.175	303	7.1	ND
SW-5	745	0.054	41	6.3 F.		SW-12	750	0.197	301	7.2	ND
SW-5	845	0.015	34	6.2 F	13.8	SW-12	850	<b>0.</b> 185	388	7	ND ND
SW-5	946	0.022	65	6.1 F	14.3	SH-12	940	0.160	272	7.1	ND
SW-5	1045	0.000	65	6.4 F	16	SW-12	1855	<b>9.</b> 137	284	7	ND
SW-5	COMP	0.023	ND	ND c é E	DA 12	SW-12	COMP	0.171	מא.	ND C 7 E	ND
SW-6	637	0.080	13	6.6 F	13	SW-13	610	0.120	305	5.7 F	18
SW-6	735	0.085	12	5.6 F	12.9	SW-13	715	Ø. 140	295	6.5 F	:2.5
SW-6	833	<b>9.865</b>	19	6.3 F	13.5	S₩-13	818	0.155	271	7 F	11.5
SH-6	932	8.048	15	6.4 F	13.9	SW-13	915	<b>%.</b> 125	310 350	6.4 F	13
S₩-6	1038	0.022	17	6.5 F	15.5	SW-13	1010	0.120	256	6.4 F	13
3 <del>V-6</del>	COMP	9. 05B	ND	ND ND	ND	SW-13	COMP	0.132	ПИ	ND	ND 10-0
SW-7	62 <b>8</b>	0.200	250	9.6 F	14.2	SEEP-1	1130	ND ND	ND ND	ND N:D	12.2
SW-7	726 906	0.200	128	7.8 F	14.5	SEEP-2	1145	ND	ON	ND ND	11.7
SH-7	826	0.170	171	3.2 F	16.7	SEEP-4	1155	ND	ND	ДИ	17.2
SH-7	925	0.110	171	9.1 F	16. 1	SEEP-5	1200	ND a area	ND ND	ND F 3 E	17.2
SH-7	1032 COMP	0.080	351 M	10.1 F ND	21 MD	SEC-A	1000	0.899 3.395	ND ND	6.3 F	15 13
SH-7	· LUMP	<b>0.</b> 152	ND	שא	ND	SEC-B	1007	3.006 a.ooo	ND NO	6.5 F	
						SEC-C SEC-D	1 <b>007</b> 1 <b>0</b> 11	0.002 0.005	NO ŪM	6.5 F 5.9 F	13.8 15.2

9 9 9			CFS	LHMOS		TEMP C			CFS	UHMOS		TEMP C
9 9 9	:====: 5W-1	1620	0.030	217 F	6.8 F	10.6	======== SH-8	1215	2.000	*======== ND	ND ND	ND
9 9 9	5W-1	1725	Ø. 180	127 F	6.6 F	10.0	SH-8	1545	0. 200	ND ND	۸D	ND
9	S₩-1	1805	0.075	147 F	6.6 F	10.2	SH-6	1645	0.000	ND	ND	ND
S	3M-1	1980	0.040	197 F	6.7 F		SW-8	1745	0.288	ND .	ND	ND
	5W-1	2005	8. 848	220 F	6.9 F	10.0	SH-8	1845	0.000	ND .	ND	ND
_	5W-1	2055	0.100	131 F	6.8 F	9.0	SW-8	1945	0.000	ND	ND	ND
9	SW-1	2105	0.750	194 F	6.8 F	9.8	SW-8	COMP	ND	ND	ND	ND
	5W-1	COMP	0.162	ND	ND.	ND	SH-9	1530	0.000	1058	6.9	11.0
	SW-2	- 1540	0.110	205 F	6.7 F	10.0	SW-9	1640	0. 250	1600	6.9	11.0
		1645	0.330		6.6 F	10.0	SH-9	1745	0.055	81	7.1	18.5
	SW-2	1740	1.180	118 F	6.3 F	9.8	SW-9	1905	0.007	68	7.2	3. 8
	5H-2	1830	0.780	148 F	6.9 F	9.3	SW-9	2010	0.000	203	6. 9	9.3
	SW-2	1945	0.600	171 F	6.9 F	8.9	SH-9	2130	0.000	109	6.9	8.9
	SH-5	2030	0.220	177 F	6.9 F	8.5	SH-9	COMP	ND	109	6.9	8.9
	2M-5	2130	0.490	158 F	6.9 F	8.5	SH-18	1550	0.320	333	7.1	ND.
	SM-5	COMP	0.530	ND	ND	ND	SW-10	1655	1.300	204	7. 1	\ <u>1</u>
	5W-3	1555	0.070	273 F	6.8 F	10.0	SH-10	1755	1.400	151	7.1	ND
	3₩-3	1655	0.300	250 F	8.5 F	10.0	SH-19	1920	0.970	214	7.1	8.5
	SW-3	1755	0.180	190 F	6.9 F	10.0	S <del>W</del> -10	5050	0.660	236	7.1	8.3
	5 <del>W</del> -3	1859	ð. 100	184 F	6.9 F	9.5	S₩-18	2145	0.600	160	7. 1	9. 0
	SW-3	1955	0.120	238 F	6.9 F	8.8	SW-10	COMP	ND	פא	ND	MD
	5W-3	2045	0.150	262 F	6.9 F	9.0	SH-11	1505	0.560	457	7.2	11.0
	3W-3	2155	0.120	212 F	6.9 F	8.9	SW-11	1715	0.020	1823	5.7	10.8
	₩-3	COMP	0.149	ND	ND	ND	SW-11	1805	0.180	450	6.6	18.5
	SW-4	1530	0.350	258 F	6.6 F	19.2	SW-11	1940	0.160	357	6.7	8.9
	5W-4	1630	0.310	238 F	6.4 F	10.0	SW-11	2040	ø. 000	ND	ND	ND
	5W-4	1730	1.500	151 F	6.9 F	9.8	SW-11	2210	0.020	80020	7.1	8.5
	3W-4	1830	0.900	173 F	6.9 F	9.4	SW-11	COMP	ND	ND	ND	ND
	5₩-4	1945	0.350	220 F	6.9 F	8.8	SH-12	1620	0.105	294	7.1	10.2
	₩-4	2030	0.470	243 F	7.0 F	8.6	SW-12	1725	0.291	325	5.2	9.2
	SW-4	2130	0.750	187 F	6.9 F	8.4	SW-12	1820	0.212	266	7.0	10.5
	SW-4	COMP	0.651	ND	ND	ND	SW-12	1950	Ø. 135	207	7.1	8.9
S	€W-5	1539	0.284	152 F	6.3 F	11.7	SW-12	2110	0.181	244	7.1	9.5
	¥-5	1630	0.026	172 F	7.0 F	11.0	SW-12	2220	<b>3.</b> 153	157	7.2	5.3
	SW-5	1730	0.024	25 F	7.4 F	10.3	SH-12	COMP	ΝD	ND	ND	ND
S	3₩-5	1830	0.014	34 F	8.0 F	9. B	SW-13	1610	ø. 100	239 F	- 6.8 F	9.6
S	SW-5	1930	0.002	48 F	7.8 F	8.8	SH-13	1705	<b>0.</b> 150	237 F	ND	10.0
S	SW-5	2030	<b>0. 04</b> 5	71 F	8.2 F	8.3	SW-13	1815	0.170	225 F	6.7 F	9.3
S	₩-5	2130	0.009	ND	ND	ND	SW-13	1910	0.110	213 F	6.9 F	9.4
S	W-5	COMP	0.018	ND	ND	ND	5W-13	2020	0.110	228 F	6.9 F	9. 1
	3¥-6	1600	0.020	45 F	8.0 F	11.8	SW-13	21 <b>05</b>	0.110	228 F	6.9 F	9.2
	₩-6	1700	0.160	15 F	7.1 F	18.7	SW-13	2215	0.110	238 F	7.0 F	9. 0
S	₩ <del>-6</del>	1805	0.100	19 F	8.9 F	10.2	SW-13	COMP	<b>0.</b> 123	ND.	ND	ND
S	₩-6	1300	0. 248	30 F	8.5 F	9.8	SEEP-1	1425	0.000	300 F	6.8 F	9.2
S	SW-6	5060	0.030	26 F	8.9 F	9.2	SEEP-2	1410	0.200	680 F	6.6 F	9. 8
	3₩ <b>-</b> 6	2100	0.160	26 F	8.1 F	8.5	SEEP-3	1405	0.000	838 F	6.9 F	9. :
S	₩-6	2200	0.030	35 F	8.8 F	8.5	SEEP-4	1490	0.900	711 F	7.5 F	9.7
	3 <del>-</del> -₩	COMP	0.077	ND	ND	ND	SEEP-5	1345	e. eee	745 F	6.6 F	10.0
	W-7	1555	0.060	1130 F	10.3 F	22.7	SEC-A	2115	t:D	177 F	7.4	ND
	₩-7	1655	0.220	101 F	7.1 F	11.5	SEC-B	2015	ND	157 F	6.5	ND
	W-7	1755	0.190	199 F	9.4 F	15.0	SEC-C	2017	ND	317 F	6.7	GM
	₩-7	1855	0.150	188 F	9.3 F	15. 1	SEC-D	2120	ND	75 F	6.3	NĐ
	₩-7	1955	0.130	346 F	9.9 F	17.7						
	W-7	2055	0.190	114 F	8.0 F	11.0						
	H-7	2155	<b>0.</b> 150	238 F	9.6 F	14.7						
S	W-7	COMP	<b>0.</b> 156	ND	ND	ND						

# SURFACE WATER METALS DATA (dissolved and total)

#### Station identification notes:

SEC  $A = 2^{\circ}A = 2$  deg. A = 2A = secondary outfall A

SW-13FD = field duplicate of SW-13

SW-RB = SW-70 = rinsate blank

SP-6A = tunnel seep A

SP-6B = tunnel seep B

SURFACE WATER SAMPLES (DISSOLVED METALS)-ASARCO

										Total
										Suspand.
		Antimony	Arsenic	Cadolus	Lopper	Lead	Mercury	Michel	line	Selids
ti aid	Anl Event	aqq	ខុត្ត	£ p w	ម្ភាគ	ppm	ppp	ង្គង	e e e e e e e e	2pa
SEC A	DIS ROUND-1	0.0800(	0.305	0.0046	0.190	0.025	6 <b>.5</b> 600(	0.03004	0.076	15.50
SEC 8	DIS ROUND-1	0.0800(	0.103	0.0100	0.880	0.075	0.5006%	0.1000	1.040	38.90
SEC C	DIS ROUND-1	0.08000	0.051	0.0319	6.638	0.025	0.50000	0.1400	2.50%	B.00
EEC E	DIS REUND-1	0.1000	0.021	0.0150	0.613	0.025	0.5000(	0.0500	9.738	13.80
9P-1	DIS ROUND-1	0.08000	0.015	0.0010	0.023	0.005(	0.50000	0.03664	9.010	123.00
SF-2	DIS ROUND-1	0.08000	0.078	0.0010	0.030	0.0053	0.5000:	0.03000	0.030	114.00
SF-4	DIS ROUND-1	0.08004	0.675	0.0030	0.050	0.0057	0.50000	0.03000	0.039	11.60
SP-5	DIS ROUND-1	0.0800(	0.2B0	0.0096	0.070	0.0120	0.5000	0.03064	0.159	174.00
Sw-01	DIS ROUND-1	0.0800<	0.041	0.00104	0.645	0.J0£J	0.50000	0.03060	0.048	24.50
S#02	DIS ROUND-1	0.08004	0.048	0.9610	0.039	0.0054	0.5099(	0.03004	0.0393	43.10
9W-03	BIS ROUND-1	0.0800(	0.083	0.0030	0.048	0.0054	0.3060(	6.03664	0.645	76.00
SH-64	BHS ROUND-1	0.08000	0.055	0.0010	0.045	0.005(	70006.0	0.0300(	0.051	±0.90
54-05	DIS ROUND-1	0.08000	9 <b>.2</b> 00	0.0050	0.131	0.005(	0.5000%	0.03000	0.219	88.90
5W-0c	DIS ROUMD-1	0.6800%	0.096	0.90160	0.425	0.0054	0.50030	0.0300(	0.085	20.30
5k - (-7	ĎIS ROUWD-1	0.08004	0.35&	6.0000	0.550	0.643	0.56000	0.03004	0.115	152.00
SW-08	DIS POUND-1	0.3:30	0.415	0.0010	0.140	0.025	0.5000.	0.63060	. 0.125	149.00
SK-09	DIS ROUND-1	0.1500	9.440	0.0056	0.638	0.038	0.5009(	0.1506	0.480	35.30
8¥-16	DIS REUND-1	<b>0.090</b> 00	3.250	0.2250	6.680	0.0050	0.50004	v.6266	5.90)	78.70
SW-11	DIS ROUND-1	0.0B004	0.575	8.65 <b>8</b> 0	0.813	0.0123	9.500(4	0.0800	1.210	74.40
SH-13	DIS ROUND-1	0.08000	0.165	0.0030	9,671	0.0950	0.50000	6.63000	0.194	47.20
54-13	DIS ROUND-1	0.09000	0.035	0.0010	ë. 625	0.005(	0.5000	0.03011	0.014	24.10
£ #-13/6	DIS ROUND-1	0.08004	0.030	0.601 <b>6</b> K	0.614	0.0054	9.50300	3.00004	0.6.E	34.40
SN -88	MIS ROW-9-1	0.08000	0.064	0.01108	6.9690	0.005.	v.5000	0.6300	(·, (//))	1.00%

SURFACE NAMES SAMENES (BIESOLVED METALS)-ASARCO

Ste 1d	Anl Event		Arsenic pps		Copper ppa					
SEC A	DIS ROUND-2	0.08000	(4.330	9.0040	0.375	0.018	0.5660	6.03007	0.10BJ	36.00
SEC B	DIS ROCHE-2	0.08664	0.050	0.0230	2,540		0.5000	0.0880		14.00
SEC C	BiS ROUND-2	0.0B00K	0.078	0.03 <b>8</b> 0	0.788		0.50400	0.1000		
SEC 0	DIS ROUND-2			0.0090	$\theta_{ab}(0)$		0.50000	0.53030		
5P-3	BIS ROBBO-2	0.06004	0.012	6.0013	0.0193	0.0050	0.5000	0.03000		
£9-0	DIS ROUND-2	0.08004	v.050	0.0010	6.0113	0.005	6.50000	0.075%		3.76
SP-J	DIE ROUND-2	0.08000	0.103	0.0010	0.00EN	0.0050	0.5000	6.03001	0.0283	
EP-4	DIS ROUND-2		0.641	0.0030	0.073	0.0050	0.50000	0.03000	0.0530	
SP-5	DIS ROLND-2	0.05004	0.054	5.6010	0.008N	0.0050	0.5000°	0.63000	0.6743	10.00
SW-61	ETE ROUND-I	0.06000	0.031	0.0010	0.075	0.010	<b>0.</b> 5000	0.03000	0.0913	52 00
Sm-62	DIE REUMB-2	0.03000	0.030	0.0015	J. 946J	0.065	0.5 <b>%</b> (0)	6.03600	),∂56	145.60
5%-(/)	DIS ROUND-2	0.68000	0.0E4	0.0000	0.068	0.00E	0.50001	0.639 <b>0</b> c	0.0890	113.00
14-04	Dia Round-2	0.08604	0.044	0.0030	0.0593	0.607	0.50164	a,03666	0.0510	147.00
S¥-05	BIE ROUND-2	0.0800%	0.781	0.6190	0.513	0.025	9.50000	- 0.03031	155	128.00
Sk-08	BIE ABUKB-2	0.08663	6.115	6.9019	0.450	0.907	0.50600	6.03660	0.1.90	18,00
Sk -67	Dis Relab-1	0.6309(	6.170	0.0010	0.253	0.025	0.500()	0.03400	6.394]	19.00
59-69	51 <b>5</b> 7 <b>8</b> 545-2	0.2500	0.319	$0.05 \cdot 0$	7.699	9.(3E	6.5660	ð. 9390	$\phi$ , $\mathbb{D}(G)$	11.00
50-10	D.S ROUND-2	0.030(<	(.365	0.9140	W.T13	0.012	A. 5/1961	6 330K	0.460	166.06
50-1:	L18 80UND-2	0.0B00(	2.2833	0.3380	17.750	0.005.	0.500	0.4565	25.400	68.00
58-115	P15 F0LN0-2	∂.≎B}0(	0.315	6:0111	).188	0.0000	50	6.0000	6.26 <b>3</b>	14.66
Sin = 2	1-0400 210	9.030t/	6,536	6.053	(.04)	0.005	\$.5.5 b	0.01%	1. C	169,96
18-11	D19 13080-2	0.0800:	0.026	6.00%	0.9113		9. <b>5</b> .3 1	6.000.	9133	15.00
5%-1350	1.2 812%5-1	3.73067	$\mathfrak{t},\mathfrak{A}_{2}$	22.804.00	0.01:3	\$1.36%.				17.60
29	011 10a.6-2	(.68a)(	6.3640	(.5.3)	5.013	0.0634	1.1.1.1.	0. 190.	6. 53 <b>ē</b>	1.46

SURFACE MATER SAMPLES (DISSOLVED METALS) HASARDO

		Antimony		Cacaius	Copper		Mercar;	Nickel	list	Total Suspend. Solids
Sta Id	Anl Event	btm		pp.a		ppa 	pp <b>b</b>	acq	ppa	acq
SEC 4	DIE ROUND-3	0.0830N	0.419	0.5033	0.275	5.015	5,50000	0.03093	0.078	14.70
SEC B	DIS ROUND-3	0.0E00N	0.175	0.00E0	1.740	9.050	0.50000	0.0830	0.670	55.10
SEC C	DIS ROUND-3	0.0800N	0.118	0.01E0	0.438	0.025	0.50000	9.6500	1.040	5.00
SEC 6	DIS 50UND-3	0.0306N	0.600	0.9140	1.180	0.025	C.5000:	0.33600	0.438	16.70
5F-1	DIS ROUND-3	0.0800N	0.017	0.001/	0.025	0.005(	0.5000t	0.03000	0.0303	1.00
SP-2	DIS RECNE-3	0.02000	0.104	0.5015	0.025	₽.005<	0.30000	0.03090	0.0350	3,89
SF-4	D19 RDUN5-3	0.0B00N	0.344	9.0010	0.063	6.0054	0.50000	0.63000	0.0553	7.06
SF-5	DIS MOUND-3	0.0B00N	0. <b>678</b>	0.0010	0.016	0.005J	0.50001	0.03036	0.094	27.90
SN-01	BIS ROUND-3	0.0B00N	0.03B	0.09160	0.075	0.006	0.5000	0.03064	0.158	€
SW-02	DIS FOUND-3	0.0000N	0.052	9.0016.	0.030	0.006	0.5000	0.0790	0.959J	
SN-63	DIS ROUND-I	0.080VN	0.123	0.0050	0.083	0.011	6.500%	6.0300(	6.143	45.30
:4-0-	D15 R00AD-0	9.0800N	0.07B	9.0017	0.061	0.006	0.500/:	0.0300.	0.9 <b>B</b> 5	13.80
5#- 35	DIS ROUND-3	0.0800M	0.316	0.6040	6.275	0.010	0.5000:	0.03000	0.331	63.10
SH-06	Dis Round-3	0.0B00N	0.193	J. 90168	6.453	0.0053	0.5000:	0.0300(	0.135	19.76
SW-(.)	DIS 1:00ND-3	0.0800N	0.208	0.00104	0.22B	6.016	0.50000	a.0305K	0.0813	207.00
£ #−0¢	D13 R0UNE-3	0.17503	0.500	(.0010	0.533	0.017	0.5006:	6.0300	9.148	2.90
Sk-10	BIS ADUNE-3	6.08004	6.470	0.0280	0.700	0.313	0.5006	0.0700	0.963	34.40
Sh-11	DIE ROUM-3	0.08000	2.50)	0.2500	10.300	0. <b>0</b> 0e	0.500%	0.1253	14.200	54.60
5W-116	DIS ROLAD-3	0.0800N	1.BE0	a.0350	1.216	0.096	0.5000	0.0500	7, 900	31,40
SW-12	DIE ROUND-3	0.6863N	0.18.	0.0650	0.125	0.005(	0.50066	0.03(0)	0.240	22.20
5W-13	DIS ABUND-I	0.08/0N	0.028	0.00101	0.025	0.0034	0.5000	0.63064	0.936h	11.20
SW-1350	DIS FOUND-3	0.0800K	v. 027	0.0000	0 015	0.098	0.5000	0.0300:	0.075J	10.30
SC-PB	D18 #.DUND-3	0.0600N	5.0644	0.0040	6.0.90	0.0051	0.50000	0.0000	3.5153	1.000

SURFACE WATER SAMPLES (TOTAL METALS)-ASARCO

Sta Id	Anl Event	Antimonv ppm	Arsanic ppm	Cadmium ppm	Copper pp <b>a</b>	Lead ppm		Nickel ppa	Zinc ppa
SEC A	TOT ROUND-1	0.0800<	0.725	0.00 <b>B0</b>	1.630	0.350	0.7090	0.0300	0.175
SEC P	TOT ROUND-1	0.1250	1.630	0.0240	4.630	1.600	3.6000	0.1160	1.350
SEC C	TOT ROUND-1	0.0900	0.360	0.0340	1.200	0.186	0.50000	0.1500	2.600
SEC S	TOT ROUND-1	0.1100	2.130	0.0310	2.340	0.963	3.1000	0.0600	0.850
SF-1	TBT ROUND-1	0.08000	0.350	0.0030	1.080	0.188	1.6000	0.07000	0.091
SF-2	TOT ROUND-1	0.08004	0.223	0.6016	0.275	0.075	1.7000	0.0300	0.073
57-4	TOT ROUND-1	0.08064	0.725	0.0636	0.124	0.025	0.5000	0.03000	0.055
SP-5	TOT ROUND-1	0.08060	43.B00	0.1650	28.800	8.5002	230.0000	0.3000	6.300
SW-01	TOT ROUNG-1	0.0800<	0.141	0.0010	0.241	0.075	0 <b>.50</b> 00(	0.0306(	0.106
SM-02	TOT ROUND-1	0.68004	0.119	0.0010	ō. i8£	6.050	0.50004	0.03060	0.108
SH-03	TOT ROUND-1	0.08004	0.245	0.0640	0.353	0.125	i.6000	0.03060	0.148
SH-04	TOT ROUND-1	0.08004	6.133	0.0030	0.25 <i>6</i>	0.075	0.5600	0.0300<	0.131
SW-05	TOT ROUND-1	0.08004	0.613	0.00B0	1.360	0.268	1.0000	0.03000	0.440
SW-04	TOT ROUND-1	0.08000	5.310	6.0010	1.306	0.175	0.5000	0.6360(	6.153
SW-07	TOT ROUND-1	0.2600	1.630	0.6110	2.880	0.550	1.5000	0.0400	0.340
SN-08	TOT ROUND-1	0.2000	2.750	0.0250	6.250	1.480	0.8000	0.0600	0.936
SN-09	TOT ROUND-1	0.2500	1.250	0.0190	3.380	1.000	1.1000	0.1900	0.550
SW-10	TOT ROUND-1	0.08004	6.130	0.2340	12.600	0.398	3.0000	0.0900	6.300
SW-11	TOT ROUND-1	0.1750	3,630	0.0500	5.630	1.160	9.4000	0.0800	1.619
SW-12	TOT ROUND-1	0.08000	0.345	0.0050	0.389	0.075	0.6000	0.03004	0.286
SW-13	TOT ROUND-1	0.08000	0.125	0.0010	0.125	0.050	0.50000	0.03000	0.049
SW-13F0	TOT ROUND-1	0.08000	0.131	0.0010	0.125	0.008	6.5000.	0.07900	0.046
SW-RE	TOT ROUND-1	0.0800(	0.0044	0.001%	0.00B(	0.005/	0.5000g	0.0300:	0.0680

SURFACE WATER SAMPLES (TOTAL METALS)-ASARCO

Sta Id	Anl Event	Antimonv ppm	Arsenic ppm		Copper ppm	Lead		Nickel pp.a	linc ppa
SEC A	TOT ROUND-2	0.1380	1,380J	0.0140	3,380	0.763	0.7000	0.03000	0,263
SEC B	TOT ROUND-2	0.1380	0.850	0.0300	5.000	0.625	1.1000	0.1130	2.410
SEC C	TOT ROUND-2	0.0800	0.245	0.0400	1.340	0.200	0.50000	0.1000	2.130
SEC D	TOT ROUND-2	0.1750	1.7503	0.0280	2.750	1.000	2.5000	0.03000	0.500
SP-1	TOT ROUND-2	0.08004	0.023	0.0010	0.059	0.010	0.50060	0.03000	0.016
SP-2	TOT ROUND-2	0.0800(	0.086	0.0010	0.03E	0.005	0.50004	0.03000	0.036
SP-3	TOT ROUND-2	0.68004	0.268	0.0036	0.026	0.0054	0.50004	0.03000	9,015
SF -4	TOT ROUND-2	0.0800	0.875	0.0030	0.0B3	0.025	0.50060	0.03000	0.055
SP-S	TOT ROUND-2	0.0B000	0.315	0.0030	0.03B	0.009	0.30000	0.03000	0.675
SW-01	TOT ROUND-2	0.0800(	0.153	0.0030	0.375	0.125	0.4000	0.03000	0.181
£₩-62	TOT ROUND-2	0.08004	0.115	0.0030	0.425	0.125	0.50000	0.0300(	0.20B
5W-03	TOT ROUND-2	0.08004	0.273	6.0650	0.475	0.200	1.7000	0.0300(	0.186
SN-04	TOT ROUND-2	0.08004	0.228	0.0640	0.488	0.125	0.8000	0.0300	0.211
SW-05	TOT ROUND-2	0.0880	1.386J	0.0310	2.940	0.550	2.4000	0.0300	1.640
54-05	TOT ROUND-2	0.08004	0.208	0.0030	0.913	0.100	0.50000	0.03000	0.128
SW-07	101 ROUND-2	0.0800	0.359	0.0040	0.925	0.150	0.50004	6.03900	0.215
SW-07	TOT ROUND-2	0.4750	0.888	0.0110	2.940	0.850	0.4000	0.0400	0.325
5W-10	TOT ROUND-2	0.0800<	1.3803	0.0240	2.590	0.413	2.4000	0.0300	1.050
5W-11	TOT ROUND-2	0.0300	5.380J	0.3560	24.750	0.338	2,3000	0.1630	21.500
5W-116	701 ROUNG-2	0.08600	0.125	0.0110	0.333	0.005N	0.7000	0.0360	0.313
SW-12	TOT SOUND-2	0.08000	2.8303	0.0683	4.750	0.338	3.6000	0.0360	3,440
SH-13	TOT ROUND-2	0.0B000	6.678	0.00100	0.354	0.025	0.50004	0.03000	0.039
SW-13FD		0.08000	0.053	0.00164	0.056	0.026	0.30000	0.03004	9.623
SW-RB	TOT ROUND-2	0.0800(	\$.004<	0.00100	6.00B(	0.005k	0.5000	0.93960	0.008(

SURFACE WITTER CHAPLES (TOTAL METALS)-ASARCE

Sta ld	Ani Event	Antisenv pps	Arseald ppa	Dadmiun pgn	Copper ppa	Lead pps	Manauny ppo	Mickel PAT	Ziáz ppa
SEC A	TOT ROUND-3	0.0800n	0.635	ε.0940	0.900	0.163	0.50001	0.03901	0.109
SEC B	167 ROUND-3	0.:380j	1.500	0.0190	5.440	1.060	1.6000	6.0660	0.415
SEC E	TOT ROUND-3	0.0E00N	0.2B0	0.02.0	0. <b>9</b> 25	0.150	0.26364	0.0100	1.026
SEC B	TOT ROUND-3	0.0800N	1.250	0.0250	2.880	0.673	1.2600	3.35(0)	0.51-
SP+:	TOT ROUND-3	0.0BG3N	0.018	0.6610	0.025	0.005	1 <b>.5</b> 00%	3.6736	2.5161
9P-1	TOY RHUND-3	0.9800N	0.113	0.0010	0.050	6.0050	6.51 000	0.070	0.030J
£β − ¢	TOP ROUND-3	0.63061	9.85£	0.9916	0.086	0.625	9.5650	6.03060	0.053
3P-5	TET FOUND-I	0.0800V	1.000	0.0630	9.450	0.050	1.5600	0.03694	9.025
\$P -c=	TOT TUNNEL	0.0830(	1530,000	41,0000	4370.000	0.160	1.40/63	9.700)	4000.000
SF-SE	TOT TUNNEL	0.08300	3.800	32.0000	3 <b>49</b> .000	0.061	9.50000	2.8.00	784,000
56-61	707 ROLNO-3	0.0200N	0 <b>.6</b> 7₺	0.000	0.156	(.025	0.56000	0.030%	0.:59
92-02	TOT ROUND-D	0.0800N	0.082	9.0016:	0.066	0.017	0.56(3)	4.,0700	6.059
38-63	16: RetND-3	O.OBOON	0.427	0.0069	0.175	0.936	0.2056	$\theta$ , $\theta$ 3000.	9.14.4
5K-34	TOT BOUND-D	0.0B00N	6.125	$\hat{\eta}_{i}, \hat{\eta}_{i+1}\hat{\eta}_{i}$	0.125	6.023	3.5006	0.936%	0.055
5.0-05	701 ROLND-3	3.0B06%	3.530	0.0090	1.200	(.186	1.7660	$\phi_{*}(0.50\%)$	0.450
58-58	101 B(05NB-3	0.0306%	0.205	0.00104	0 7 <b>E</b> 3	0.053	0.50€€	0.0300	6.698
£(;=0)	TET REENE-1	0.11363	9.511	0.6950	1,445	(.238	3. 26 %	).0136:	9.209
$\mathfrak{M}_{\mathcal{G}^{n}}(\mathcal{G}_{\mathcal{G}})$	TO FRIEND OF	0.26003	0.315	3.0010	5.715	330.)	9.5 900	0.0330	3.513
EN-10	TOT REUND-1	0.0500%	0.792	0.03.0	1.180	0.075	6.56 6	9.0300	1.950
Si-11	707 EUROPE	0.68004	5 350	0.2530	15,000	9,030	0.500	6 1250	3.696
£1116	HIL ROUNDED	0.0800N	J.753	d.Orad	4.389	6,460		0.056	F. 500
SWORT	not become	0.9800%	<b>0.</b> 300	200	7 <b>.</b> 115	0.608	1.57.91	0.039.	37. 4
\$4-13	TOTAL TOURS - 1	0.05.08	0.341	9.3	5.138	1,03	4.5% 4	1. 2%	0. 957
$\mathbb{S}_{\mathcal{F}} \leq \mathbb{C} \mathbb{F}_{2}^{n}$	761 RBb15514	0.0000A	3.5-3	7.0.13	4.138	0.903	0.50	9.9	6,115.
5,5-65	TO 1 (FLUX) 13	0.43008	1. 14.4	5.1511	0.5,90	0.005/	1.5166	5 To	5.73

SURFACE WATER ORGANICS DATA (acids, base/neutrals, PCB)

### Station identification notes:

DUPLICAT = SW-13FD = field duplicate of SW-13 SEC A = 2°A = 2 deg. A = 2A = secondary outfall A MB-SW = method blank for round 1 METH-11 = method blank for round 2 SW-70 = SW-RB = rinsate blank

SURFACE WATER SAMPLES - (ACIDS)

Sta Id	Anl	Event	Fenta chloro phenol ppb	Phenol ppb	2,4,5-Tri chloro phenol ppb	2,4,6-Tri chlara phenal ppb	Biphenyls ppb	Dibenza thiophene ppb	Dimethyl analine ppb	Methyl phenan threnes ppb	1 methyl 12-methyl ethylbenz ppb
DUPLICAT	TOT	ROUND-1	50.004	10.00(	50.00(	10.004	10.00N	10.00N	10.00N	10.00	10.00N
MB-SW	TOT	ROUND-1	50.00<	10.00<	50.00<	10.00(	10.00N	10.00N	10.00N	10.00	10.00N
SEC A	TOT	ROUND-1	100.00(	20.00{	100.004	20.004	20.00N	20.00N	20.00N	20.00N	20.00N
SEC B	TOT	ROUND-1	50.00<	10.00{	50.004	10.004	10.00N	10.00N	10.00N	10.00N	10.00N
SEC C	101	ROUND-1	50,004	10.004	50.00(	10.004	10.00N	10.00N	10.00N	10.00N	10.00N
SEC D	TOT	ROUND-1	50.000	10.00{	50.00<	10.00<	10.00N	10.00H	10.00N	10.00N	10.00M
SP-1	TOT	ROUND-1	50.00(	10.004	50.00(	10.004	10.00N	10.00N	10:00N	10.00N	10.00N
SP-2	TOT	ROUND-1	50.00(	10.00{	50.000	10.000	10.00N	10.00N	10.00N	10.00N	10.00N
SP-4	TOT	ROUND-1	50.00{	10.004	50.000	10.00(	10.00N	10.00N	10.00N	10.00N	10.00N
SP-5	TOT	RDUND-1	50.00(	10.000	50.004	10.004	10.00N	10.00N	10.00N	10.00N	10.00N
5W-01	101	ROUND-1	50.00(	10.004	50.00(	10.000	10.00N	10.00N	10.00N	10.00N	10.00N
SW-02	TOT	ROUND-1	50.00(	10.00<	50.00{	10.00<	10.00N	10.00N	10.00N	10.00N	10.00N
SN-03	TOT	ROUND-1	50.00<	10.004	50.00<	10.00(	10.00N	10.00N	10.00N	10.00N	10.00N
SW-04	TOT	ROUND-1	50.00(	10.00(	50.000	10.004	10.00N	10.0011	10.00N	10.00N	10.00N
SW-06	TOT	RDUND-1	100.00(	20.00{	100.064	20.00(	20.00N	20.00N	20.00N	20.00N	20.00N
SW-07	TOT	ROUND-1	50.00<	10.00(	50.00<	10.00<	10.00N	10.00N	10.00N	10.00N	10.00N
SN-08 ··	TOT	ROUND-1	50.00<	10.004	50.000	10.000	10.00N	10.00N	10.00N	10.00N	10.00N
SW-09	TOT	ROUND-1	50.004	10.004	50.00<	10.004	10.00N	10.00N	10.00N	10.00N	10.00N
SW-11	TOT	ROUND-1	100.00(	20.004	100.000	20.004	20.00M	20.00N	20.00N	20.00N	20.00N
5W-12	101	ROUND-1	50.00(	10.004	50.004	10.004	10.00N	10.009	10.00N	10.00N	10.00N
SW-13	TOT	ROUND-1	50.00<	10.004	50.004	10.000	10.00N	10.00N	10.00N	10.00N	10.00N
SN-70	101	ROUND-1	200.004	40.000	200.004	40.004	40.00N	40.00N	40.00N	40.00N	40.00N
HETH-11	TOT	ROUND-2	50.00(	10.00{	50.00(	10.004	10.00N	10.00N	10.00N	10.00N	10.00N
5W-03		ROUND-2	50.004	10.00<	50,000	10.000	10.00%	10.00N	10.00N	10.00N	10.00N
SW-06		RDUND-2	50.004	10.000	50.004	10.004	10.00N	10.0CM	10.00H	10.00N	10.00N
5#-10		ROUND-2	50.004	10.004	50.00(	10.00(	10.00N	10.00N	10.00N	10.00N	10.00N
SW-11		ROUND-2	100.004	20.004	100.004	20.00(	20.00N	20.00N	20.00N	20.00N	20.00N
SW-70		ROUND-2	50.004	10.004	50.004	10.000	10.00N	10.00N	10.00N	10.00N	10.00N

SURFACE WATER SAMPLES - (ACIDS)

Sta Id	Anì	Event	Benzoic Acid ppb	2-Chloro phenol ppb	2.4-Di chloro phenai ppb	2,4-Di methyl phenol ppb	2,4-Di nitro phenal ppb	2-Hethyl pheno! ppb	4-Methyl phenol ppb	2-Nitro phenol ppb	4-Nitro phenal ppà	4-Chloro- 3-methyl phenol ppb
DUPLICA	T TOT	ROUND-1	50.00(	10.00(	10.00(	10.00(	50.00<	10.00{	10.00<	10.00{	50.00{	10.004
MB-SH	101	ROUND-1	50.004	10.000	10.00(	10.000	50.004	10.00<	10.00(	10.004	50.000	10.00(
SEC A	TOT	ROUND-1	100.000	20.00(	20.00<	20.000	100.00(	20.00{	20.00<	20.00(	100.00(	20.004
SEC B	101	ROUND-1	50.004	10.004	10.004	10.00(	50,004	10.00{	10.00(	10.000	50.00{	10.00(
SEC C	TOT	RBUND-1	50.00(	10.000	10.00(	10.004	50.00(	10.00{	10.004	10.00<	50.00(	10.004
SEC D	TOT	ROUND-1	50.00{	10.00<	10.000	10.00(	50.00(	10.000	10.000	10.004	50.00(	10.00
SP-1	101	ROUND-1	50.004	10.000	10.004	10.00(	50.000	10.004	10.000	10.000	50.004	10.004
5P-2	101	ROUND-1	50.0 <b>0</b> (	10.00(	10.00(	10.000	50.004	10.00{	10.000	10.000	50.004	10.000
SF-4	TOT	ROUND-1	50.004	10.00(	10.00(	10.004	50.000	10.000	10.000	10.00<	50.00(	10.00(
SP-5	101	ROUND-1	50.00(	10.004	10.00<	10.000	50.004	10.00<	10.000	10.00<	50.00(	10.00(
SW-01	TOT	ROUND-1	50.0 <b>0</b> <	10.004	10.00(	10.000	50.004	10.00(	10.00<	10.000	50.00(	10.00
SH-02	101	ROUND-1	50.00(	10.00(	10.00(	10.00(	50.00<	10.00(	10.00(	10.00<	50.00{	10.004
5N-03	TOT	ROUND-1	50.004	10.00(	10.004	10,000	50.004	10.000	10.000	10.000	50.004	10.00(
SW-04	TOT	ROUND-1	50.004	10.000	10.00(	10.004	50.00(	10.00(	10.004	10.00(	50.00{	10.004
SM-04	TOT	ROUND-1	100.00<	20.00(	20.00(	20.004	100.000	20.004	20.00(	20.00(	100.00{	20.00{
SW-07	TOT	ROUND-1	50.004	10.004	10.00(	10.00(	50.004	10.00(	10.000	10.00(	50.00(	10.00(
SW-08	TOT	ROUND-1	59.000	10.00(	10.00(	10.004	50.00<	10.000	10.000	10.00(	50.00(	10.00(
5W-09	TOT	ROUNG-1	50.000	10.000	10.00(	10.00<	50.004	10.00(	10.00<	10.00(	50.00(	10.000
SW-11	101	ROUND-1	100.00<	20.004	20.004	20.00<	100.004	20.004	20.00<	20.004	100.00(	20.00(
5¥-12	TOT	ROUND-1	50.004	10.00<	10.004	10.000	50.00(	10.00<	10.000	10.00(	50.00(	10.00{
SW-13	TOT	ROUND-1	50.000	10.000	10.00(	10.000	50.00(	10.000	10,004	10.00(	50.00(	10.00<
SW-70	TOT	ROUND-1	200.00(	40.000	40.000	40.004	200.00{	40.000	40,000	40.00(	200.004	40.00(
HETH-11	TOT	ROUND-2	50.000	10.00(	10.000	10.000	50.000	10.00<	10.00(	10.004	50.00<	10.00<
5N-05	101	ROUND-2	<b>5</b> 0.0 <b>0</b> <	10.000	10.00(	10.0 <b>0</b> 0	50.00(	10.00<	10.000	10.00{	50.00<	10.00<
2N-09	101	ROUND-2	50.09(	10.004	10.004	10.004	50.00(	10.000	10.00(	10.000	50.004	10.004
SW-10	101	ROUND-2	50.00(	10.064	10.004	10.000	50.00(	10.004	10.000	10.000	50.000	10.00{
SW-11	TOT	ROUND-2	100.00<	20.00(	20.004	20.000	100.000	20.00<	20,004	20.00(	100.000	20,000
SW-70	101	ROUND-2	50.004	10.000	10.000	10.004	50.004	10.004	10.004	10.00{	50.00(	10.00<

Parametrix Inc. -- Environmental Data System SURFACE WATER SAMPLES - (BASE NEUTRALS)

			Ace naohthene	Acenaph thylene	Aniline	Anthrarne	Benzidine	Benzo(a)	Benza(a) pyrene	Benzo(b) fluor anthene	•	Benzo(k) fluor anthene	Benzyl Alcahol	bis(2-chl oroethoxy )methane
Sta Id	Anl	Event	ppb	bbp	ppb	\$p <b>p</b>	bbp		bbp	ppb	ppb	ppb	ppb	ppb
DUPLICAT	TOT	ROUND-1	10.004	10.00<	10.00(	10.004	80.00(	10.00(	10.00<	10.00<	10.00<	10.00<	10.00<	10.00<
MB-SM	TOT	ROUND-1	10.00(	10.00{	10.00(	10.00(	80.000	10.00{	10.00<	. 10.004	10.004	10.00<	10.000	10.09(
SEC A	TOT	ROUND-1	20.00(	20.00<	20.00<	20.000	200.00(	20.00<	20.000	20.004	20.000	20.00(	20.00{	20.00<
SEC B	TOT	ROUND-1	10.00{	10.00{	10.00(	10.000	80.00(	10.000	10.00N	10.00N	10.00N	10.00N	10.00(	10.00(
SEC C	TOT	ROUND-1	10.004	10.00<	10.00(	10.00<	B0.00{	10.00{	10.00(	10.00{	10.00<	10.00(	10.00{	10.004
SEC D	TOT	ROUND-1	10.00<	10.00<	10.00	10.00{	B0.00{	10.00<	10.00<	10.00(	10.00<	10.00<	10.00{	10.00<
SP-1	TOT	ROUND-1	10.00(	10.00<	10.00(	10.00(	80.00<	10.00<	10.00<	10.00{	10.00<	10.004	10.00<	10.00<
SP-2	TOT	ROUND-1	10.00(	10.004	10.004	10.00<	B0.00(	10.00<	10.00<	10.00<	10.00<	10.00(	10.00<	10.00<
SF-4	TOT	ROUND-1	10.00<	10.00<	10.00<	10.00<	B0.00(	10.00(	10.00<	10.00(	10.00<	10.00{	10.00(	10.00<
SP-5	TOT	ROUND-1	10.00{	10.004	10.004	10.00<	80.00<	10.00(	10.00N	10.00N	10.00N	10.00N	10.004	10.004
5W-01	TOT	ROUND-1	10.00{	10.004	10.004	10.00{	B0.00{	10.00(	10.00{	10.000	10.00<	10.000	10.00(	10.004
SW-02	TOT	ROUND-1	10.000	10.00<	10.00<	10.00<	B0.00(	10.00(	10.00<	10.00<	10.00<	10.004	10.00<	10.00<
SW-03	TOT	ROUND-1	10.00(	10.004	10.00<	10.00(	B0.00(	10.00(	10.00(	10.00<	10.00<	10.00<	10.00(	10.00<
SW-04	TOT	ROUND-1	10.60<	10.00(	10.00(	10.00<	B0.00<	10.00<	10.000	10.00<	10.00(	10.00<	10.000	10.00<
Sk-04	TOT	ROUND-1	20.00<	20.00<	20.004	20.00<	160.000	20.00<	20.00<	20.00(	20.00<	20.00{	20.000	20.00<
S#-07	TOT	ROUND-1	10.00<	10.00<	10.000	10.004	60.00	10.00{	10.000	10.000	10.004	10.004	10.00(	10.000
SH-08	TOT	ROUND-1	10.00<	10.00/	10.00<	10.00<	80.00<	10.00<	10.00<	10.00<	10.00<	10.00<	10.00<	10.00<
SW-09	TOT	ROUND-1	10.004	10.00<	10.00{	10.004	B0.004	10.00(	10.000	10.004	10.006	10.00{	10.004	10.00(
SW-11	TOT	ROUND-1	20.00{	20.004	20.004	20.00<	160.004	20.00<	20.00<	20.00{	20.00<	20.004	20.00{	20.004
5W-12	TOT	ROUND-1	10.00<	10.000	10.00(	10.00{	B0.00(	10.00(	10.004	10.00<	10.000	10.004	10.00(	10.000
SN-13	TOT	ROUND-1	10.00(	10.00<	10.004	10.00(	B0.00<	10.00(	10.000	10.00(	10.000	10.00<	10.00<	10.000
SK-70	TOT	ROUND-1	40,004	40.00<	40.000	40.00<	300.00(	40.00<	40.000	40.004	40.00<	40.004	40.00<	40.000
METH-11	TOT	ROUND-2	10.00<	10.00{	10.004	10.000	80.00(	10.004	10.00<	10.00<	10.00<	10.00<	10.000	10.000
SW-05		ROUND-2	10.00<	10.00<	10.00<	10.004	80.004	10.004	10.00<	10.004	10.00<	10.00<	10.000	10.000
SW-08	TOT	ROUND-2	10.000	10.00{	10.00{	10.000	80.00(	10.00(	10.00(	10.00{	10.00{	10.00(	10.000	10.000
SW-10		ROUND-2	10.000	10.00{	10.00{	10.00<	80.004	10.00<	10.00<	10.004	10.00<	10.004	10.000	10.000
SW-11	TOT	ROUND-2	20.00<	20.004	20.004	20.00<	160.00<	20.00(	20.00<	20.00{	20.00<	20.00<	20.00<	20.004
SN-70		ROUND-2		10.000	10.00<	10.000	80.004	10.00<	10.004	10.00<	10.00<	10.00(	10.000	10.00(

Parametrix Inc. -- Environmental Data System SURFACE WATER SAMPLES - (BASE NEUTRALS)

Sta Id	Anl Event	bis(2-chl oroethyl) ether ppb	bis(2-chl oroisopro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Brosoph enyl-phen yl ether ppb	Butyl benzyl phthalate ppb	4-Chloro aniline ppb	2-Ehloro naphthlne ppb	4-Chlorop henyl phe nyl ether ppb	Chrysene ppb	Dibenzo (a,h) anthracne ppb	Dibenzo furan ppb	1,2- Dicloro benzene ppb
DUPLICA	TOT ROUND-1	10.00<	10.000	10.00<	10.00<	10.00(	10.00(	10.00<	10.00<	10.00(	10.00(	10.00<	10.00
MB-SW	TOT ROUND-1	10.004	10.00<	10.00(	10.00(	10.00(	10.00(	10.00<	10.00<	10.00(	10.00(	10.00{	10.00{
SEC A	TOT ROUND-1	20.00<	20.00<	110.00	20.00<	20.00<	20.00	20.00(	20.06<	20.00{	20.004	20.00<	20.00<
SEC B	TOT ROUND-1	10.00(	10.00{	10.00<	10.00<	10.00{	10.000	10.00<	10.004	10.00<	10.00N	10.00	10.00(
SEC C	TOT ROUND-1	10.00(	10.00	20.00	10.00<	10.00<	10.00(	10.00<	10.00<	10.00<	10.00<	10.00<	10.00{
SEC D	TOT ROUND-1	10.000	10.00<	10.00<	10.00<	10.00<	10.00(	10.00<	10.00<	10.00	10.00<	10.004	10.00<
SP-1	TOT ROUND-1	10.00{	10.004	10.000	10.004	10.00<	10.00(	10.00(	10.00<	10.00{	10.00(	10.00(	10.00{
SP-2	TOT ROUND-1	10.00(	10.00<	10.00<	10.000	10.00<	10.00{	10.00<	10.00<	10.00(	10.000	10.00<	10.00<
SP-4	TOT ROUND-1	10.00<	10.00(	10.00<	10.00{	10.00<	10.00{	10.00<	10.00<	10.00<	10.00<	10.00{	10.00<
SF-5	TOT ROUND-1	10.004	10.00{	10.00<	10.00	10.00<	10.00(	10.00<	10.00<	10.00<	10.00N	10.00{	10.004
SN-01	TOT ROUND-1	10.00<	10.000	10.00<	10.000	10.00<	10.00(	10.00(	10.00<	10.00<	10.00<	10.00<	10.00(
5W-02	TOT ROUND-1	10.00<	10.60	10.000	10.000	10.00(	10.00(	10.00{	10.00<	10.00(	10.000	10.004	10.00<
SN-03	TOT ROUND-1	10.00<	10.00	10.00<	10.000	10.00<	10.00(	10.00{	10.000	10.00(	10.00(	10.00<	10.00(
SN-04	TOT ROUND-1	10.00{	10.00<	10.00<	10.60<	10.00<	10.004	10.000	10.00<	10.00<	10.00<	10.00{	10.00<
SN-06	TOT ROUND-1	20.00<	20.00<	20.00(	20.00<	20.00<	20.00<	20.00(	20.004	20.00(	20.000	20.00<	20.00(
SW-07	TOT ROUND-1	10.00<	10.00(	10.00<	10.0 <b>0</b> <	10.00<	10.000	10.00<	10.00(	10.00<	10.000	10.000	10.004
SN-08	TOT ROUND-1	10.00<	10.00<	10.00<	10.00(	10.000	16.0 <b>0</b> (	10.000	10.00(	10.00(	10.004	10.000	10.00(
SK-09	TOT ROUND-1	10.00{	10.00(	10.00<	10.00<	10.00<	10.0 <b>0</b> (	10.00<	10.00<	10.000	10.000	10.000	10.00<
SW-11	TOT ROUND-1	20.00<	20.00<	20.00(	20.00<	20.00<	20.000	20 <b>.00</b> <	20.004	20.00{	20.004	20.004	20.00(
SW-12	TOT ROUND-1	10.00(	.10.004	10.00<	10.0 <b>0</b> <	10.00(	10.004	10.00(	10.00(	10.00<	10.00<	10.000	10.00(
SW-13	TOT ROUND-1	10.00(	10.000	10.00{	10.00<	10.000	10.00(	10.00<	10.00(	10.00{	10.000	10.00<	10.004
SW-70	TOT ROUND-1	40.004	40.000	40.00<	40.00<	40.00<	40.000	40.00<	40.00<	40.00(	40.00<	40.000	40.004
METH-11	TOT ROUND-2	10.00(	10.000	10.000	10.004	10.000	10.000	10.00<	10.000	10.000	10.000	10.000	10.00<
SW-05	TOT ROUND-2	10.00{	10.000	20.00	10.000	10.004	10.000	10.00<	10.004	10.000	10.00(	10.00<	10.000
SW-06	TOT ROUND-2	10.00<	10.00(	10.00<	10.004	10.00<	10.000	10.004	10.000	10.000	10.00<	10.000	10.004
SW-10	TOT ROUND-2	10.000	10.00(	10.004	10.004	10.000	10.000	10.000	10.00<	10.00<	10.000	10.00(	10.000
SW-11	TOT ROUND-2	20.00(	20.004	20.004	20.00<	20.00<	20.000	20.00(	20.000	20.004	20.004	20.00(	20.00(
S₩-70	TOT ROUND-2	10.000	10.004	10.00(	10.000	10.004	10.00(	10.00(	10.004	10.004	10.004	10.000	10.004

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Parametrix Inc. -- Environmental Data System SURFACE WATER SAMPLES - (BASE NEUTRALS)

Sta Id	Anì	Event	1,3- Dichloro benzene ppb	1,4- Dichloro benzene ppb	3,3'- Dichloro benzidine ppb	Diethyl phthalate ppb	Disethyl phthalate ppb	Di-n- Butyl phthalate ppb	2,4- Dinitro toluene ppb	2,6- Dinitro toluene ppb	Di-n- Octyl Phthalate ppb	Fluor anthene ppb	Fluorene ppb	Hexa chloro benzene ppb
DUPLICAT	 TNT	ROUND-1	10.00(	10.00<	20.00<	10.00<	10.00(	10.000	10.004	10.00(	10.00<	10.00<	10.00<	10.00<
MB-SW		ROUND-1	10.000	10.00{	20.00	10.00(	10.000	10.00(	10.000	10,000	10.004	10.004	10.00{	10.00<
SEC A		ROUND-1	20.004	20.004	40.004	20.00(	20.00(	20.004	20.004	20.004	20.004	20.004	20.00<	20.00<
SEC B		ROUND-1	10.00{	10.004	20.00(	10.00(	10.00(	10.004	10.000	10.004	10.00N	10.00{	10.004	10.004
SEC C		ROUND-1	10.00K	10.000	20.004	10.000	10.004	30.00	10.000	10.00(	10.00<	30.00	10.00<	10.00<
SEC D		RDUND-1	10.004	10.000	20.00(	10.00(	10.000	10.00<	10.000	10.00<	10.004	10.00(	10.000	10.00<
SP-1	TOT	ROUND-1	10.004	10.00{	20.00(	10.000	10.004	10.00<	10.000	10.00(	10.004	10.00<	10.00(	10.00<
5P-2	TOT	RDUND-1	10.00(	10.000	20.00<	10.00(	10.00(	10.000	10.00(	10.00{	10.000	10.00{	10.00(	10.00(
SP-4	TOT	ROUND-1	10.00<	10.000	20.00{	10.004	10.00(	10.000	10.00<	10.00(	10.00(	10.00<	10.00(	10.00(
SP-5	TOT	RDUND-1	10.00<	10.004	20.00(	10.000	10.00(	10.00(	10.00<	10.00{	10.00N	10.00(	10.00(	10.00(
SW-01	TOT	RDUND-1	10.004	10.004	20.00<	10.00(	10.000	10.00(	10.000	10.000	10.00{	10.00{	10.00<	10.004
SN-02	TOT	RDUND-1	10.00<	10.00(	20.00(	10.000	10.00<	10.000	10.00(	10.00<	10.00(	10.00{	10.00(	10.000
SN-03	TOT	ROUND-1	10.00<	10.00€	20.00(	10.000	10.00<	10.00<	10.00<	10.00(	10.00<	10.00<	10.00<	10.00<
5N-04	101	ROUND-1	10.00(	10.00<	20.00<	10.000	10.00	10.00<	10.00(	10.00<	10.00(	10.00<	10.00<	10.004
SW-06	101	RDUND-1	20.00<	20.004	40.00<	20.00(	20.00<	20.00<	20.00<	20.004	20.00<	20.00{	20.00<	20.00(
5N-07	TOT	round-1	10.00<	10.00<	20.00<	10.00<	10.000	10.00<	10.00<	10.00(	10.000	10.004	10.00<	10.00(
SW-08	TOT	round-1	10.00<	10.00<	20.00<	10.00<	10.00<	10.00(	10.00<	10.00<	10.00<	10.00<	19.00(	10.00{
SH-09	707	round-1	10.00<	10.00<	20.00(	10.00<	10.00(	10.00<	10.00<	10.00<	10.00<	10.00(	10.00<	10.000
SN-11	TOT	ROUND-1	20.00{	20.0 <b>0</b> <	40.00{	20.004	20.00<	20.004	20.004	20.00(	20.00<	20.004	20.004	20.00{
5W-12	701	ROUNG-1	10.00<	10.000	20.00<	10.00<	10.00<	10.000	10.00<	10.00<	10.000	10.00<	10.00<	10.00<
SW-13	TOT	ROUND-1	10.00<	10.004	20.000	10.000	10.00(	10.00<	10.00(	10.00<	10.00<	10.00<	10.000	10.000
SW-70	TOT	round-1	40.00<	40.00<	80.00<	40.00<	40.00<	40.00(	40.00<	40.00{	40.000	40.000	40.000	40.00<
METH-11	TOT	RBUND-2	10.004	10.00<	20.004	10.00<	10.000	10.00<	10.004	10.004	10.004	10.004	10.00<	10.00(
SK-05	TOT	ROUND-2	10.00<	10.00(	20.00(	10.004	10.00(	10.004	10.00(	10.004	10.004	10.00<	10.00<	10.00(
SW-OA	TOT	ROUND-2	10.004	10.00<	20.004	10.000	10.00(	10.000	10.004	10.000	10.004	10.000	10.000	10.00<
SW-10		ROUND-2	10.00(	10.000	20.00(	10.000	10.000	10.00(	10.00(	10.00<	10.00<	10.004	10.00(	10.004
SW-11	TOT	ROUND-2	20.00<	20.00<	40.00<	20.004	20.004	20.00(	20.00(	20.004	20.00(	20.004	20.00<	20.004
SW-70	TOT	ROUND-2	10.004	10.00<	20.00<	10.00{	10.000	10.000	10.00(	10.00{	10.000	10.004	10.004	10.00(

Parametrix Inc. -- Environmental Data System SURFACE WATER SAMPLES - (BASE NEUTRALS)

	•		Hexa chloro butadiene	Hexachlor ocyclopen tadiene	Hexa chloro ethane	Indeno (1,2,3-cd Pyrene	lso phorone	2-Hethyl naphthlne	Naphthlne	2-Nitro aniline	3-Nitro aniline	4-Nitro aniline	Ki tro benzene	N-Nitroso dimethyl amine
Sta Id	Anl	Event	ppb	ppb	bbp	<b>р</b> рь	ppb	ppb	ppb	ppb	· ppb	ppb	ppb	ppb
DUPLICAT	TOT	ROUND-1	10.00(	10.00	10.00(	10.00{	10.00(	10.00€	10.00(	50.004	50.00{	50.00<	10.00(	10.000
MB-SN	TOT	ROUND-1	10.00<	10.00<	10.00(	10.00{	10.00(	10.00<	10.00<	50.00<	50.00<	50.00<	10.00(	10.00(
SEC A	TOT	ROUND-1	20.00(	20.00<	20.00(	20.00(	20.00{	20.0 <b>0</b> <	20.00(	100.00(	100.00<	100.00{	20.00<	20.00<
SEC B	TOT	ROUND-1	10.00{	10.00<	10.00(	10.00N	10.00{	10.00<	10.000	50.00<	50.0 <b>0</b> <	50.00<	10.00<	10.00<
SEC C	TOT	ROUND-1	10.00<	10.00<	10.00{	10.00<	10.00(	10.00	10.00{	50.00<	50.00<	50.00<	10.00(	10.00<
SEC D		ROUND-1	10.000	10.00(	10.000	10.00<	10.000	10.000	10.00(	50.004	50.004	50.00{	10.000	10.00
SP-1		ROUND-1	10.00{	10.004	10.00{	10.00(	10.00<	10.0 <b>0</b> (	10.00	50.00(	50.004	50.004	10.00{	10.00(
SP-2		ROUND-1	10.00(	10.00<	10.004	10.00<	10.00(	10 <b>.00</b> (	10.004	50.00<	50.00<	50.00<	10.00(	10.000
SP-4		ROUND-1	10.00	10.00(	10.00<	10.00(	10.00	10.00(	10.0 <b>0</b> <	50.00<	50.00<	50.00{	10.00<	10.000
SF-5		ROUND-1	10.00<	10.00<	10.00<	10.00N	10.000	10.00<	10.0 <b>0</b> (	50.00<	50.00<	50.00{	10.00(	10.00(
5W-01		ROUND-1	10.00{	10.00(	10.00<	10.00<	10.000	10.000	10.004	50.00<	50.00<	50.00(	10.00(	10.00<
SN-02		ROUND-1	10.00{	10.00<	10.004	10.00<	10.000	10.00(	10.000	50.00<	50.004	50.00<	10.000	10.0 <b>0</b> <
SN-03		ROUND-1	10.00{	10.00{	10.00<	10.00<	10.00(	10.00{	10.004	50.00	50.00(	50.00(	10.000	10.0 <b>0</b> <
SW-04		ROUND-1	10.00(	10.00{	10.00<	10.00<	10.00(	10.000	10.00<	50.00<	50.004	50.00{	10.00(	10.0 <b>0</b> <
SH-06		ROUND-1	20.00{	20.00<	20.00<	20.00(	20.00<	20.00(	20.00<	100.00<	100.00<	100.004	20.00(	20.00{
SN-07		ROUND-1	10.00<	10.00<	10.00(	10.00<	10.00<	10.00<	10.0 <b>0</b> <	50.000	50.00<	50.004	10.000	10.00(
SN-08	TOT	ROUND-1	10.00{	10.00<	10.00(	10.00{	10.000	10.00<	10.00<	50.00<	50.004	50.00(	10.00<	10.000
5W-09	TOT	ROUND-1	10.00(	10.00<	10.000	10.000	10.000	10.00(	10.00<	50.00{	50.000	50.00<	10.00<	10.00<
SW-11	TOT	ROUND-1	20.00(	20.00<	20.00<	20.004	20.00<	20.00(	20.00<	100.004	100.000	100.004	20.00<	20.0 <b>0</b> (
SW-12	TOT	ROUND-1	10.00<	10.00<	10.00<	10.000	10.00(	10.00(	10.00{	50.004	50.0 <b>0</b> <	50.00(	10.00<	10.004
5H-13	TOT	round-1	10.00<	10.00<	10.000	10.00(	10.000	10.00<	10.000	50.004	50.00(	50.00(	10.000	10.00<
SW-70	TOT	ROUND-1	40.00<	40.00(	40.000	40.004	40.00{	40.004	40.000	200.004	200.000	200.004	40.00<	40.00(
METH-11	TOT	ROUND-2	10.00<	10.00<	10.00<	10.000	10.00(	10.000	10.00(	50.004	50.00(	50.00<	10.000	10.00(
SN-05	TOT	ROUND-2	10.000	10.004	10.000	10.000	10.000	10.004	10.004	50.000	50.004	50.00(	10.00<	10.000
SK-09	TOT	ROUND-2	10.00<	10.000	10.000	10.000	10.00(	10.004	10.000	50.004	50,00(	50.00<	10.00(	10.00
SW-10	TOT	RDUND-2	10.00(	10.00<	10.000	10.000	10.00(	10.004	10.00(	50.004	50.00(	50.00(	10.00(	10.000
SW-11	TOT	ROUND-2	20.00<	20.00<	20.000	20.004	20.004	20.000	20.004	100.004	100.000	100.004	20.00(	20.000
SW-70	TOT	ROUND-2	10.00<	10.004	10.000	10.004	10.00<	10.00(	10.000	50.004	50.00(	50.00(	10.00(	10.000

SURFACE WATER SAMPLES - (BASE NEUTRALS)

			N-Nitroso dipropyl amine	N-Nitroso diphenyl amine(1)	Phen anthrene	Pyrene	1.2,4-Tri chloro benzene	PCBs
Sta Id	Àn1 l	Event	ppb	ppb	ppb	ppb	ppb	ppb
DUPLICAT	TOT I	RDUND-1	10.00{	10.00{	10.004	10.004	10.00(	2.00(
MB-SW	TOT	ROUND-1	10.00(	10.00<	10.00(	10.00(	10.00<	1.00(
SEC A	TOT I	ROUND-1	20.00(	20.00(	20.00(	20.004	20.00{	2.00(
SEC B	TOT	ROUND-1	10.000	10.00<	10.00<	10.00<	10.00<	2.004
SEC C	TOT I	ROUND-1	10.00{	10.00(	10.00<	10.00(	10.00<	2.00<
SEC D	TOT I	ROUND-1	10.00(	10.00<	10.00<	10.00<	10.004	5.00(
SP-1	TOT F	1-ONUOS	10.00<	10.00<	10.00<	10.00(	10.004	2.00<
SP-2	TOT F	1-0NU08	10.00(	10.004	10.00<	10.00	10.00<	2.00<
SP-4	TOT F	ROUND-1	10.00{	10.00{	10.00<	10.00<	10.00<	2.00<
SF-5	TOT F	ROUND-1	10.00(	10.00(	10.000	10.004	10.00<	2.00<
5₩-01	TOT F	I-DANO	10.00(	10.00<	10.00(	10.00<	10.00<	2.00<
5W-02	TOT F	ROUND-1	10.00<	10.00<	10.00<	10.00(	10.00<	2.00<
SW-03	TOT F	1-0400	10.00(	10.00<	10.00<	10.00<	10.00<	2.004
SN-04	TOT F	ROUND-1	10.00<	10.00<	10.00<	10.00<	10.004	2.00<
SW-04	101 5	RDUND-1	20.00<	20.004	20.00<	20.00(	20.004	
SW-07	TOT F	ROUND-1	10.00(	10.00<	10.00<	10.000	10.004	2.00(
SW-08	TOT F	ROUND-1	10.00{	10.00<	10.00<	10.00(	10.00(	2.000
SW-09	TOT F	ROUND-1	10.00<	10.00<	10.00(	10.00<	10.00<	2.00{
SW-11	TOT F	ROUND-1	20.00(	20.00(	20.00(	20.00{	20.00<	
SW-12	TOT F	ROUND-1	10.00(	10.000	10.00(	10.00(	10.00<	2.00(
SW-13	TOT F	KOUND-1	10.004	10.00<	10.00<	10.00<	10.00<	2.00<
SW-70	TOT F	1-0400	40.00<	40.00<	40.00<	40.000	40.00{	2.00<
METH-11	TOT F	ROUND-2	10.00{	10.004	10.000	10.000	10.000	1.000
SN-05	TOT F	ROUND-2	10.000	10.000	10.00{	10.004	10.00<	5.004
SW-06	TOT F	ROUND-2	10.000	10.000	10.00<	10.00(	10.00(	5.00(
SW-10	TOT F	ROUND-2	10.00<	10.000	10.00<	10.00<	10.00<	5.00<
54-11		ROUND-2	20.00<	20.00<	20.00<	20.00<	20.004	5.00<
SW-70	TOT R	DUND-2	10.00{	10.00<	10.00<	10.004	10.004	5.00<

APPENDIX I

SURFACE SOIL

	Hercury	Antimony	Arsanic	Cadaius	Chromium	Copper	Lead
Stald Anl Event	ppb	the	tba	bbæ	ppn	рра	ր <b>ր</b> ո
SHW-4-TH TOT ROUND-1	4470.0000J	19.0000	278.000	2.2000J	41,000	2593,000	258.000J
SMW-5-TM TOT ROUND-1	10400,0000J	13.0000(	205.000	7.3000J	45.660	3383.000	415.0003
SMA-7-TM TOT ROUNG-1	32 <b>6</b> 00.00003	139.0000	10000.000	430,00003	55.000	13400.000	72500.0003
SMW-8-TM TOT ROUNG-1	2560.0000J	36,0000	3080.000	£0.0000J	142.000	11025.000	5500.000J
SMW10-TM TOT ROUND-1	3080.000 <b>0</b> J	13.00000	1218.000	25.00003	58,000	1635.000	1235.000J
EMMII-TH TOT ROUND-1	23700.6000J	13.00000	1165.000	35.0000J	82.000	695,000	513.060J
SMW12-TM TOT ROUND-1	2700.00003	13.0000	E33,000	12.0000J	76.000	3270.000	1030.0003
SNR13-TH TOT ROUND-1	140.00003	13.0000(	11.000	0.4830J	43.000	41,000	12.00ĉJ
SS-01-TH TOT ROUND-1		385.0000	28760,000	343.000CJ	42,000	12250.000	17975.000J
SE-02-TH TOT ROUND-1		3350.0000	262250.000	208.00003	25.000	17200.000	£450.000J
SS-03-TH TOT ROUND-1	56300.0000J	790.0000J	17825,000	90.0000J	89.000	37375.000	2750.000J
SS-04-TH TOT ROUND-1	13700.00003	41.0000	33225.000	18.000GJ	66.000	17000.600	2413,6003
SS-06-TH TOT ROUND-1	25806.0000J	172.0000J	14975,000	50.0000J	78.000	25525.000	4000.0003
SS-GB-TH TOT ROUND-1	20700.00003	13.00004	1918.000	3.00003	93.000	155.000	55.000J
SS-05ATM TOT HOUNG-1	27300.0000J	13.00000	13750,000	73.00003	92.006	9500,006	130.000J
SS-GRETH TOT MOUND-1	33800.0000J	13.00000	15400.000	87.000 <b>0</b> J	67.000	10700.003	137,6003
55-10-TH TOT ROUND-1	217000.00000	147.0000	17225.000	148.000GJ	49.000	9825.000	7890,000J
SS-11-TH TOT ROUND-1	37500.0000J	147,0000	10825.000	B2.0000J	40.000	7050.000	5775.0003
55-12-7H TOT ROUND-1	405000.00 <b>00J</b>	855.0000	15975.000	132.00003	30.000	8275.000	22225,0000
SS-13-TH TOT ROUND-1	42400.0000J	47,0000	13525.000	123.00003	59.000	5378.000	4400.0003
SS-16-TM TOT ROUND-1	7260.00003	25.0000	1998,000	49B.0000J	39.000	3118,000	9375.060J
SE-19-TH TOT ROUND-1	15400.000 <b>0</b> J	13,00000	5245,000	18.0000J	45.000	4635.000	1623,0000
99-20-TM TOT ROUND-1	695000.0000J	548.0000	23050.000	138.9000J	37.000	7050.000	£375.000J
SE-21-TH TOT ROUND-1	170000.00003	540.0000	21175.000	335.00003	21.000	5725.000	19000.0003
SS-22-TK TOT ROUND-1	68700.00003	223.0000	13115.000	118.0000J	<b>52.0</b> 00	4885.000	7250.0003
55-23-18 TOT ROUND-1	107000.0000J	253.0000	17175.009	199.00001	43.000	<b>8375.</b> 000	0825.0003
SS-24-TH 707 ROSMD-1	5060.00003	13.00000	1469.006	12.0000 <b>J</b>	45.000	£48.00	<b>7</b> 59.0000
SS-15-TH TOT MOUND-1	11100.00003	13.000%	4,25,006	£9.0060J	5 <i>6</i> .000	1833.000	1793.0002
SS-26-TH TUT ROUND-1	101000.00000	13.00000	5583.000	41.00000	<b>5</b> 2.000	18:5.000	3125.0003
ES-27-TK TOT ROUND-1	574000.00003	78.0000	10200.000	£12.0000J	60.000	4437.000	4700.0003
SE-28-IN TOT NOUND-1	97200.0000J	<b>30.</b> 000 <b>0J</b>	9775, (36	£3.50000	42.000	10075.000	3550.000J
SS-29-78 TOT ROUND-1	27750.000 <b>03</b>	13.00000	24859,000	44.00001	64.000	3535.000	2550,0003

SURFICIAL SOIL SAMPLES (METALS) -ASARCO

			Marcury	Antimony	Arsenic	Cadaius	Chromium	Copper	Lead
Sta Id	Anl	Event	ppb	ppæ	bha	рра	ppa	bba	bby
SS-30-TM	TOT	ROUND-1	34900.0000J	13.0000{	1845.000	17.0000J	46.000	505.000	713.0003
SE-31ATM	TOT	ROUND-1	159000.0000J	25.0000	8225.000	69.00003	48.000	2383,000	4100.000J
SS-318TM	TOT	R0UND-1	166000.00003	34.0000	£275.000	67.0000J	46.000	2345.000	4200.000J
SS-32-TH	181	ROUNG-1	4960.0000J	13.0000(	708.000	15.0000J	55.000	1443.000	165.000J
SS-33-TM	TOT	ROUND-1	63200.0000J	14.0000	4125,000	41.0000J	48.000	895.600	1028.000J
SS-34-TN	TOT	ROUND-1	11300.0000J	13.00004	1468.000	70.000 <b>0J</b>	<b>55.0</b> 00	3015.000	1650.000J
\$5-35-TM	TOT	ROUND-1	5270.0000J	13.00004	425.000	24.0000J	54.000	1122.000	226.000J
SS-36-7M	TOT	ROUND-1	444000.0000J	226.0000J	8100.000	198.0000J	45.000	8175.000	15225.000J
SS-37-TM	TOT	ROUND-1	6650.00003	13.0000N	780.000	11.0000J	74.000	1985.000	258.000J
NT-85-28	rot	ROUNE-1	171000.0000J	90.0000	1155.000	94.0000J	77.000	4553.000	3925.000J
55-39-TH	TOT	ROUND-1	15900.0000J	13.0000(	4698.000	9.3000 <b>J</b>	47.000	535.000	137.000J
SS-40-Th	TOT	ROUND-1	211600.6000J	52.0000J	9250.000	92.0000J	50.000	1995.000	4150.0003
SS-41-TM	TOT	ROUND-1	106000.00003	57.000 <b>0</b>	5173.000	78.0000J	70.000	2033.000	4078.000J
55-42-TM	TOT	ROUND-1	119000.0000J	114.0000	<b>9375.</b> 000	70.0000J	49.000	9700.000	3950.000J
SS-43-TM	TOT	ROUND-1	44700.00003	216.0000	5250.000	32.00003	54.000	5275.000	2500.000J
55-44-TM	TOT	RSUND-1	58300.00000	30.0000	2828.000	Ja.6600J	50.000	2335.000	1995.000 <b>J</b>
SS-45-TK	TOT	ROUND-1	183000.0000J	40.0000	600.000	B0.0000J	∆1.000	10750.000	2478.000J
55-46-TM	TOT	ROUND-1	70500.0000J	101.0000	8525.000	33.0000J	67.000	9800.000	3300.00 <b>0</b> J
SS-47-TH	TOT	ROUND-1	88200.0000J	74.00003	10500.000	21.0000J	52,000	2128.000	4400.0003
SS-48-TK	101	ROUND-1	70100.00003	14.00003	2973.000	i2.0000J	74,000	2078.000	177 <b>8.</b> 000J
55-49-TH			23700.0000 <b>J</b>	13.00004	1573.000	13.0000J	59.000	80 <b>0.</b> 000	700.000J
SS-50-TK			1520.0000 <b>J</b>	13.00000	435.000	3.500 <b>0</b> J	49.000	505.000	121.960J
55-51-7M	101	ROUND-1	9110.0000J	70.0000	1373.000	31.0000 <b>J</b>	41.000	31675,960	4025.040J
98-52-TN	Tüt	ROUND-1	7800.0060J	170.0000	2095.000	17.0000J	59.000	34825.000	5025.000J
SS-53-TM	TOT	ROUND-1	10000.0000J	124.0000	1855.000	19.00003	50.00 <b>0</b>	22500.000	3825,0003
SS-34-TH			21600.00063	87.0000	1958.000	20.00000	58,000	1 <b>94</b> 75.000	3900.000J
55-55-TM			2430.00003	13.0000	820.000	7.80003	94.000	4615.000	1203.000 <b>J</b>
35-56-TM			10800.0000J	13.0000(	1273.006	9.5000J	72,000	10175.000	1638.0002
SS-57-TH			5460.00003	13.00064	112.000	5.80991	49,000	1107.000	248.0003
SS-SBATM			£170.0000J	78.0000	1113.000	8.2000J	<b>59.</b> 000	341250,000	2455.300J
SS-SBBTK			5 <b>750.0000</b> J	70.0000	1043.000	9.0060J	43.000	272250.000	2238.0000
88-59-TH	TOT	ROUND-1	<b>45</b> 30.00003	215.0000	940.000	9.50001	26.000	29500.009	405.0003

SURFICIAL SOIL SAMPLES (METALS)-ASARCO

	Mercurv	Antiaony	Arsenic	Cadmium	Chromium	Copper	Lead
Sta Id Anl Event	ppb	ppm	ppm	ppa	ppa	ppa	ppa
SS-60-TM TOT ROUND-	1 10900.0000J	63.0000	1373.000	31.0000J	51.000	25725.000	4075.000J
SS-61-TH TOT ROUND-	1 7310.0000J	13.0000<	2020.000	53.0000J	BO.000	483B.000	2230.000J
SS-62-TH TOT ROUND-	1 6610.0000J	13.00004	590.000	7.5000J	119.000	5572.000	1283.0003
SS-63ATM TOT ROUND-	1 5640.0000J	13.00004	540.000	B.3000J	66.000	4960.000	B95.000J
SS-63BTM TOT ROUND-	1 5860.0000J	13.0000<	600.000	9.3000J	60.000	<b>5453.0</b> 00	1020.0003
SS-64-TH TOT ROUND-	1 9690.0000J	13.00004	1248.000	B.0000J	67.000	9425.000	1273.000J
SS-65-TM TOT ROUND-	1 1960.00003	13.00004	160.000	5.3000J	61.000	1510.000	310.000J
SS-66-TH TOT ROUND-	1 3060.0000J	13.0000(	170.000	2.8000J	50.000	2593.000	244.000J
SS-67-TM TOT ROUND-	1 1070.0000J	13.0000(	24.000	0.2500N	35.000	136.000	16.000J
SS-68-TH TOT ROUND-	1 5710.00003	13.00004	117.000	0.9300J	32.000	685.000	102.000J
55-69-TM TOT ROUND-	i 1430.0000J	13.00004	330.000	2.8000J	65.000	6375.000	30B.000J
SS-70-TM TOT ROUND-	1 1670.00003	13.0000<	473.000	8.5000J	71.000	<b>3923.000</b>	775.000J

			Nickel	Selenius	Silver	Thallium	Zinc	Barius
Sta Id	Anl	Event	opa	ppa	ppæ	ppm	рра	ppa
SMW-4-TM	TOT	ROUND-1	185.0000	22.0000	12.0000	13.0000	360.000	125.00
SHW-5-TH	TOT	ROUND-1	68.0000	24.0000	9.0000	13.00004	293.000	104.00
SMN-7-TM			93.0000	18.0000	31.0000	13.00004	2495.000	583.00
SMN-8-TM	TOT	ROUND-1	165.0000	18.0000	42.0000	13.0000<	5850.000	360.00
SMN10-TH	TOT	ROUND-1	55.0000	18.0000	7.0000	13.0000<	958.000	167.00
SMW11-TM			75.0000	20.000 <b>0</b>	3.3000	13.0000<	910.000	150.00
SHN12-TH	TOT	RDUND-1	78.0000	13.0000	11.0000	13.0000<	2150.000	154.00
SMW13-TM			60.0000	18.0000	1.5000	13.0000<	39.000	97.00
SS-01-TH	TOT	RDUND-1	60.0000	192.0000	73.0000	23.0000	2950.000	142.00
SS-02-TH	TOT	ROUND-1	43.0000	274.0000	103.0000	20.0000	2400.000	70.00
SS-03-TH	TOT	ROUND-1	140.0000	77.0000	85.0000	13.0000<	4775.000	139,00
SS-04-TH	TOT	ROUND-1	115.0000	39.0000	25.0000	13.00004	2195.000	122.00
SS-06-TM	TOT	ROUND-1	123.0000	43.0000	B0.0000	13.00064	4600.000	305.00
SS-08-TM	TOT	ROUND-1	100.0000	18.0000	2.5000	13.00000	120.000	147.00
SS-09ATH	TOT	ROUND-1	183.0000	22.0000	2.0000	13.00000	14800.000	128.00
SS-09BTH	TOT	ROUND-1	175.0000	18.0000	2.0000	13.0000<	16500.000	123.00
SS-10-TH	TOT	ROUND-1	55.0000	75.0000	<b>59.</b> 0000	13.00000	1955.000	183.00
SS-11-TM			70.0000	54.0000	37.0000	13.00000	2355.000	125.00
SS-12-TM			45.0000	96.0000	78.0000	20.0000	1788.000	103.00
SS-13-TM	TOT	ROUND-1	56.0000	37.0000	26.0000	13.00004	1145.000	184.00
SS-16-TM	101	ROUND-1	15.0000	26.0000	3.5000	13.00004	890.000	142.00
SS-19-TH	TOT	ROUND-1	B3.0000	30.0000	21.0000	13.00000	1648,000	139.00
SS-20-TH	TOT	ROUND-1	53.0000	1BB.0000	36.0000	18.0000	1875.000	111.00
SS-21-TM	101	ROUND-1	20.0000	100.0000	53.0000	28.0000	1B03.000	186.00
SS-22-TH	TOT	ROUND-1	53.0000	47.0000	34.0000	13.00000	4275.000	153.00
SS-23-TH	TOT	ROUND-1	55.0000	43.0000	46.0000	13.00090	2088.000	133.00
SS-24-TM	TOT	ROUND-1	53.0000	22.0000	4.0000	13.0000(	207.000	83.00
SS-25-TM	TOT	ROUND-1	50.0000	14.0000	8.3000	13.00000	813.000	100.00
SS-26-TH	TOT	RGUND-1	50.0000	52.0000	15.0000	13.00000	833.000	147.00
55-27-TM			75.0000	179.0000	25.0000	13.0000(	2215.000	167.00
SS-28-TM	TOT	ROUND-1	B5.0000	41.0000	35.0000	13.00004	3175.000	175.00
98-29-TH	101	ROURD-1	B3.0000	41.0000	169.0000	13.00000	232,000	126.00

SURFICIAL SOIL SAMPLES (METALS)-ASARCO

			Nickel	Selenium	Silver	Thallium	Zinc	Barium
Sta Id	Aal	Event	pp <b>s</b>	ppa	ppa	pp≘	ppm	pp.s
SS-30-TH	TOT	ROUND-1	48.0000	24.0000	2.5000	13.0000(	285.000	B3.00
SS-31ATM	TOT	ROUND-1	53.0000	56.0000	16.0000	13.00004	1160.000	142.00
SS-31BTM	TOT	ROUND-1	48.0000	66.0000	14.0000	13.0000<	1113.000	139.00
55-32-TM	TOT	ROUND-1	65.0000	9.0000	2.5000	13.0000<	375.000	89.00
SS-33-TM	TOT	ROUND-1	53.0000	B7.0000	4.8000	13.0000<	615.000	12B.00
55-34-TM	TOT	ROUND-1	68.0000	22.0000	8.5000	13.0000<	1500.000	150.00
55-35-TM	TOT	ROUND-1	55.0000	13.0000	1.5000	13.00004	152.000	131.00
55-36-TM	101	ROUND-1	40.0000	123.0000	47.0000	15.0000	2825.000	131.00
SS-37-TM	101	ROUND-1	80.0000	13.0000	3.8000	13.0000<	33B.000	139.00
55-38-TN	TOT	ROUND-1	85.0000	100.0000	23.0000	13.00004	1988.000	195.00
SS-39-TH	TOT	ROUND-1	50.0000	22.0000	1.3000	13.0000<	31B.000	63.00
SS-40-TH	TOT	ROUNG-1	55.0000	77.0000	17.0000	13.00004	1500.000	111.00
55-41-TM	TOT	ROUND-1	65.0000	75.0000	15.0000	13.60004	1790.000	125.00
55-42-TH	TOT	ROUND-1	88.0000	41.0000	37.0000	13.00004	3750.000	238.00
55-43-TM	TOT	ROUND-1	135.0000	24.0000	26.0000	13.00004	4300.000	208.00
SS-44-TM	TOT	ROUND-1	55.0000	24.0000	11.0000	13.0000(	1759.000	122.00
SS-45-TH	TOT	ROUND-1	58.0000	60.0000	12.0000	13.00004	1628.000	114.00
55-46-TH	TOT	ROUND-1	88.0000	30.0000	32,0000	13.00004	3600.000	164.00
SS-47-TM	TOT	ROUND-1	53.0000	104.0000	32.0000	13.00004	B45.000	147.00
SS-48-TH	TOT	ROUND-1	68.0000	20.0000	11.0000	13.00000	973.000	250.00
55-49-TM	TOT	ROUND-1	55.0000	2B.0000	5.8000	13.00000	415.000	72.00
SS-50-TM	TOT	ROUND-1	98.0000	13.0000	2.5000	13.00000	142.000	83.00
SS-51-TH	TOT	ROUND-1	125.0000	175.0000	165.0000	13.00000	B4B.000	1390.00
39-52-TM	TOT	ROUND-1	125.0000	227.0000	283.0000	13.00004	575.000	778.00
SS-53-TH	TOT	ROUND-1	113.0000	188.0000	93.0000	13.00000	513.000	1250.00
SS-54-TM	TOT	ROUND-1	113.0000	177.0000	138.0000	13.00000	655.000	1055.00
\$3-55-TH	TOT	RDUND-1	80.000	13.0600	13.0000	13.00000	638.000	117.00
SS-56-TH	TOT	ROUND-1	85.0000	58.0000	69.0000	13.0000(	305.000	805.00
SS-57-TH	TOT	ROUND-1	45.0000	11.0000	5.3000	13.00000	158.000	92.00
SS-SBATM	101	ROUND-1	575.0000	146.0000	495.0000	13.00000	370.000	1528.00
		ROUND-1	500.0000	139.0000	503.0000	13.00000	360.600	1390.00
55-59-TM	161	ROUND-1	75.0000	211.0000	2075.0000	13.00000	383.000	350.00

SURFICIAL SOIL SAMPLES (METALS)-ASARCO

			Nickel	Selenium	Silvar	Thallium	Zinc	Barium
Sta Id	'An1	Event	ppa	pps	acq	bto	ppm	bta
SS-60-TM	TOT	ROUND-1	113.0000	154.0000	150.0000	13.0000(	905.000	500.00
SS-61-TH	101	ROUND-1	103.0000	18.0000	15.0000	13.00000	2115.000	278.00
SS-62-TM	101	ROUND-1	115.0000	28.0000	<b>27.00</b> 00	13.00000	B78.000	<b>5</b> 55.00
SS-63ATM	TOT	ROUND-1	73.0000	22.0000	16.0000	13.00000	425.000	158.00
SS-63BTM	TOT	ROUND-1	75.0000	20.0000	15.0000	13.00004	460.000	175.00
SS-£4-TH	TOT	ROUND-1	110.0000	18.0000	43.0000	13.0000<	£60.000	214.00
SS-65-TM	TOT	RGUND-1	55.0000	9.0000	4.0000	13.0000{	413.000	142.00
SS-LA-TM	TOT	ROUND-1	50.0000	9.0000	6.3000	13.0000<	173.000	89.00
SS-67-TH	TOT	ROUND-1	25.0000	20.0000	1.5000	13.00004	78.300	72.00
SS-48-TM	TOT	ROUND-1	45.0000	20.0000	4.0000	13.00004	2£3.000	78.00
SS-69-TM	TGT	ROUND-1	63.0000	20.0000	B.8000	13.00000	166.000	92.00
SS-70-TH	TOT	ROUND-1	75.0000	18.0000	7.3000	13.0000	295.000	125.00

Parametrix Inc. -- Environmental Data System SURFICIAL SOIL SAMPLES - ASARCO (EP TOXICITY)

			Arsenic	Cadwium	Chronium	Copper	Lead	Hercury	Selenium	Silver	Zinc	Barius	рН
Sta Id	Anl	Event	ppa	pps	рра	pp∎	ppe	рръ	ppm	ppa	b <b>be</b>	ppa	
95-01-EP	EPT	ROUND-1	90.000	0.0720	0.020{	1.500	0.037	0.5000N	0.0830<	0.0080<	3.800	0.10<	6.7
SS-02-EF	EPT	ROUND-1	610.000	0.0100	0.020(	0.980	0.04B	0.5000N	0.0830(	0.0080<	0.700	0.104	5.5
SS-03-EF	EPT	ROUND-1	0.160	0.09203	0.0204	3B.000	0.048	0.5000N	0.0B30K	0.00804	2.700	0.10	5.4
SS-04-EF	EPT	ROUND-1	2.700	0.0320	0.020<	18.000	0.020{	0.5000N	0.0B30<	0.0080<	0.500	0.20	6.0
SS-06-EF	EPT	ROUND-1	0.410	0.3300J	0.020<	59.000	0.100	0.5000N	0.0830<	0.00B0<	17.000	0.104	5.3
SS-08-EF	EPT	ROUND-1	7.700	0.0070	0.020<	0.050	0.020<	0.5000N	0.0830<	0.0080<	0.067	0.20	8.4
SS-09AEP	EPT	ROUND-1	55.000	1.5000	0.020<	<b>65.000</b>	0.047	0.5000N	0.0B36<	0.0080<	62.000	0.10<	3.9
SS-09BEP	EPT	ROUND-1	57.000	1.3000	0.020<	<b>6B.000</b>	0.065	1.3000J	0.0830<	0.0080<	64.000	0.104	3.7
SS-10-EP	EPT	ROUND-1	<b>84.0</b> 00	1.0000	0.020<	103.000	0.640	0.5000N	0.0830<	0.0080<	40.000	0.10<	4.3
SS-11-EF	EPT	ROUND-1	5.200	0.0330	0.020<	5.300	0.020<	0.5000N	0.0830<	0.00B0<	0.800	0.10<	5.0
SS-12-EP	EPT	ROUNG-1	2.800	0.0870	0.020<	10.000	0.200	0.5000N	0.0B30{	0.0060<	0.950	0.10<	4.7
SS-13-EF	EPT	ROUND-1	13.000	0.0770J	0.020{	8.400	0.023	0.500GN	1.7000	0.0080<	2.200	0.10<	4.6
SS-16-EF	EPT	ROUND-1	17.000	0.B000	0.020<	60.000	0.050	0.5000J	0.0830<	0.0080<	26.000	0.10	3.2
SS-19-EF	EPT	ROUND-1	4.200	0.0270	0.020<	4.100	0.020	0.5000N	0.0830<	0.0080<	0.970	0.104	4.7
SS-20-EF	EPT	ROUND-1	430.000	0.0610	0.020<	1.900	0.072	0.5000%	0.0830<	0.00804	3.800	0.10	6.9
SS-21-EF	EPT	ROUND-1	13.000	0.2500	0.020<	4.800	0.037	0.5000N	0.1000	0.0090<	13.000	0.20	5.0
55-22-EF	EPT	ROUND-1	13.000	0.0950	0.020<	1.800	0.077	0.5000N	0.0B30<	0.00804	2.400	0.20	6.9
55-23-EF	EPT	ROUND-1	22.000	0.0630	0.020<	2.400	0.065	0.5000N	0.08304	0.00B0(	0.970	0.10<	7.4
SS-24-EF	EPT	ROUND-1	3.100	0.00B0J	0.020<	0.600	0.033	0.500CN	4.2000	0.00B0<	0.400	0.10<	5.9
SS-25-EF	EPT	ROUND-1	6.300	0.06803	0.020<	1.100	0.020<	0.B000J	B.3000	0.00BOK	1.300	0.104	5.2
SS-26-EF	EPT	ROUND-1	5.400	0.1000J	0.070(	1.100	0.045	0.70003	6.8000	0.00304	2.400	0.104	5.6
SS-27-EF	EPT	ROUND-1	170.000	0.0320	0.020<	0.930	0.07B	0.5000N	0.0830<	0.00804	1.60Ò	0.104	6.7
SS-28-EF	EPT	ROUND-1	21.000	0.0620	0.020<	9.400	0.022	1.60003	0.0830(	0.0080<	4.900	0.20	6.4
SS-29-EF	EPT	ROUND-1	5.700	0.2400	0.020<	8.700	0.280	0.5000N	0.0B30<	0.00804	4.800	0.20	8.3
		ROUND-1	3.200	0.17003	0.020<	2.700	0.380	0.5000N	0.0B30(	0.00804	4.500	0.104	4.7
SS-31AEP	EFT	ROUND-1	6.300	0.1600	0.020<	2.200	0.030	1.40003	0.0830<	0.00804	6.600	0.10<	5.7
SS-31BEF	EPT	ROUND-1	5.000	0.1500	0.020	2.400	0.037	1.90003	0.08304	0.00804	5.100	0.10	5.6
55-32-EF			1.000	0.04B0J	0.020<	2.200	0.020(	0.5000N	0.08304	0.00804	0.970	0.10	5.4
SS-33-EF			12.000	0.1400	0.020(	0.450	0.035	0.5000N	0.0830(	0.00800	2.000	0.20	7.B
		ROUND-1	3.500	0.1500	0.0204	1.500	0.040	0.5000N	0.0B30<	0.00B04	2.600	0.30	8.6
SS-35-EF	EPT	ROUND-1	0.110	0.1600J	0.0204	1.400	0.200<	0.5000N	0.08300	0.00800	0.630	0.100	4.8

SURFICIAL SOIL SAMPLES - ASARCO (EP TOXICITY)

Sta Id	Anl	Event	Arsenic ppa	Cadmium ppm	Chronium ppa	Copper ppa	Lead ppa	Mercury ppb	Selenium ppa	Silver ppm	Zinc ppm	Bariuz ppm	βH
SS-36-EP			18.000	0.1200	0.020(	1.900	0.110	0.60003	0.0830<	0.00B0(	2.600	0.40	6.7
55-37-EP			0.540	0.01B0J	0.0204	1.200	0.020{	0.5000N	0.0B30<	0.0080(	0.380	0.30	5.3
SS-3B-EF			12.000	0.1200	0.0204	2.600	0.085	0.4000J	0.0830<	0.0080(	2.900	0.30	7.8
SS-39-EP			35.000	0.0520	0.020{	5.500	0.020	0.5000N	0.0830<	0.0080<	5.B00	0.10(	4.0
\$5-40-EP	EFT	ROUND-1	5.500	0.1900	0.020(	1.100	0.230	1.1000J	0.0830<	0.0080<	3.500	0.10	6.3
SS-41-EP	EPT	r.03ND-1	0.820	0.25003	6.020(	1.300	0.770	0.5000N	0.0B30<	0.0086<	3.600	0.164	7.3
SS-42-EP	EPT	ROUND-1	13.000	0.1100	0.020<	B. 200	0.040	3.00003	0.03304	0.0030<	4.500	0.104	6.5
SS-43-EP	EPT	ROUND-1	3.300	0.0480	0.020(	2.900	6.048	3.40001	0.0830<	0.0080(	1.400	0.30	£.5
55-44-EP	EPT	ROUND-1	2.000	0.1300	0.020<	3.700	0.110	0.E0003	0.0830<	0.00B0K	2,200	0.10<	6.2
SS-45-EP	EPT	ROUND-1	11.000	0.2300	0.0204	1.800	0.190	0.80003	0.08300	0.0026<	5.500	0.10	£.7
SS-46-EP	EPT	ROUND-1	13.000	. 0.0720	0.020<	20.000	0.052	6.8000J	0.0830<	0.00800	2.900	0.10	6.0
SS-47-EP	EPT	ROUND-1	0.042	0.02B0J	0.020(	1.600	0.0204	0.5000N	0.0B30<	0.00804	0.320	0.10	4.3
SS-4B-EP	EFT	ROUND-1	0.150	0.0520J	0.020(	3.000	0.035	0.50003	0.08304	0.0080(	1.200	0.30	5.3
55-49-EP	EPT	ROUND-1	2.500	0.0870	0.0204	1.000	0.052	0.5000N	6.0B30K	0.00B0K	1.500	0.100	5.8
SS-50-EP			3.Bú0	0.0130	0.0204	1.100	0.020(	0.5006N	0.0830<	0.00804	0.430	0.104	5.4
SS-51-EP			0.089	0.1400J	0.020(	121,000	0.440	0.5000N	0.0830	0.00800	2.300	0.40	6.2
5S-52-EP	EPT	ROUND-1	0.090	0.061GJ	0.020(	154.000	0.310	0.5000N	0.0830(	0.00800	2.100	0.60	5.7
SS-53-EP	EPT	ROUNE-1	0.100	0.040 <b>0</b> J	0.0204	49.000	0.140	0.5000N	0.0830(	0.00804	0.850	0.30	6.3
SS-54-EF			0.070	0.05703	0.020(	35.000	0.083	0.5600N	0.0830<	0.0080(	2.000	0.10	5.8
SS-55-EP			0.120	0.0300J	0.020<	5.300	0.058	0.50000	0.08304	0.00804	0.570	0.30	5.B
\$5-54-EP			0.980	0.04803	0.020(	28.000	0.050	0.5000N	0.0830<	0.0080(	0.7EQ	0.10	5.4
SS-57-EP			0.020	6.03303	0.0204	1.600	0.020	0.5000k	6.68304	0.00864	0.230	0.10	5.5
SS-58AEP			0.130	0.05301	0.0204	61,300	0.280	0.50CON	0.00304	0.00300	0.820	1.60	B.4
SS-SBEEF			0.130	0.0520J	0.0204	81,000	0.260	0.5000A	0.0E30K	0.0030(	0.770	1.00	B.J
55-59-EF			0.110	0.08503	0,010<	195,000	1.300	0.5000#	0.68394	0.00B0K	2.600	1.00	6.7
83-60-EP			0.110	0.35000	0.0260	217.000	1.669	0.5000N	0.0830	0.00200	4.300	0.30	5.8
SS-61-EP			1.100	0.0£0 <b>0J</b>	0.0204	1.165	0.030	0.5000N	0.0830(	0.00800	1.130	0.100	6.0
SS-62-EP			0.780	0.0253J	0.0264	3,500	0.032	0.5000W	0.0830(	0.00 <b>0</b> 0.	0.34.0	0.100	5.8
SS-63AEP			0.170	0.0280J	0.0201	6.600	9.120	0.5600N	6.0830:	0.0030(	2.030	0.40	5.8
	-	ROUND-1	0.450	0.02 <b>0</b> 0J	0.020(	3.700	0.042	0.96663	0.68360	0.00800	0.920	0.10	5.7

Parametrix Inc. -- Environmental Data System SURFICIAL SOIL SAMPLES - ASARCO (EP TOXICITY)

Sta Id Anl Event	Arsenic ppm	Cadmium ppm	Chromium ppm	Copper ppm	Lead ppm	Mercury ppb	Selenium ppm	Silver ppm	Zinc ppm	Barium ppm	рН
										rr~ 	
SS-64-EP EPT ROUND-1	0.120	0.0220J	0.020(	3.400	0.026	0.5000N	0.0830<	0.0080<	0.570	0.10	5.4
SS-65-EP EPT ROUND-1	0.110	0.0120J	0.020<	0.570	0.020	0.5000N	0.0830<	0.00804	0.780	0.20	5.4
SS-66-EP EPT ROUND-1	0.170	0.0080	0.020<	0.800	0.020	0.5000N	0.0830{	0.0080<	0.150	0.104	5.4
SS-67-EP EPT ROUND-1	0.030	0.0070J	0.020{	0.033	0.020<	0.5000N	0.0830<	0.0080<	0.033	0.10	6.1
SS-68-EP EPT ROUND-1	0.090	0.0050J	0.020<	1.900	0.020(	0.5000N	0.0830<	0.0080<	0.130	0.10	7.3
SS-69-EP EPT ROUND-1	0.370	0.01003	0.020<	3.700	0.020<	0.5000N	0.0B30<	0.0080<	0.120	0.10	6.1

		Antimony	Arsenic	Cadaius	Chromium	Copper	Lead	Kercury	Nickel	Zinc
Sta Id	Anl Event	ppe	bba	abe	ppa	aqq	æςq	ppb	ppa	ррв
552-01	TOT ROUND-2	2 41.0000J	3450.000	7.8000	94.000	4625.000	1693,000	20.0000J	79.0000	440.000
\$\$2-02	TOT ROUND-2	2 13.0000N	170.000	4.3000	54.000	1065.006	345.000	18.0000J	43.0000	201.000
SS2-03	TOT ROUND-2	2 <b>39.00</b> 00J	1845.000	8.8000	79.000	6125.000	1303.000	18.00000	68.0000	390.000
552-04	TOT ROUND-2	2 343.0000J	1675.000	14.0000	45.000	62250.000	4525.000	11.00000	140.0000	550.000
SS2-05	TOT ROUND-2	2 <b>57.</b> 0000J	620.000	11.0000	94.000	7000.000	1303.000	5.20003	84.0000	328.000
SS2-05A	TOT ROUND-1	2	182.000J							
992-058	TOT ROUND-1	2	3025.000J							
SS2-05C	TOT ROUND-2	2	1655.000J							
SS2-0&	TOT ROUNG-1	2 45.0000J	2975.000	22.0000	<b>65.0</b> 00	4475.000	1693.000	34.00063	59.0000	450.000
SS2-04A	TOT ROUND-S	2	<b>6050.000</b> 3							
SS2-06B	TOT ROUND-2	2	2775.000J							
SS2-060	TOT ROUND-	2	460.000J							
SS2-07	TOT ROUND-1	2 177.0000J	4200.000	23.0000	57.000	<b>6</b> 050.000	2925,000	52.00003	45.0000	1045.000
ES2-08	TOT ROUND-1	2 13.0000N	953.000	7.5000	62.000	903.000	915.000	14.0000J	40.0000	149.000
SS2-09	TOT ROUND-2	2 13.0000N	1078.000	7.3000	51.000	90B.000	920,000	32.0000J	34.0000	169.000
SS2-10	TOT ROUND-:	2 13.0000N	495.000	5.0000	48.000	62B.000	403,000	B.2000J	33.0000	134.000
SS2-11	TOT ROUND-2	2 23.0000J	1788.000	6.5000	51.000	1325.000	945.000	15.0000J	41.0000	239.000
SS2-12	TOT ROUND-1	2 13.0000N	328.000	4.0000	51.000	610.000	265.303	3.00003	42.0000	97.000
SS2-12A	TOT ROUND-:	?	378.000J							
SS2-12B	TOT ROUND-2	2	300.000J							
SS2-12C	TOT ROUND-2	2	340.0003							
SS2-13	TOT ROUND-2	2 13.0000N	925.000	8.0000	45.000	555,006	923,060	22.00003	34.0000	172.000
991-14	TOT ROUND-1	2 53.0000J	2775.000	8.0000	56.000	2043,000	1595,000	25.00000	55.0000	426.000
SS2-14A	TOT ROUND-1	2	31.0001							
552-145	TOT ROUND-:	2	18.0003							
582-140	TOT ROUND-1	2	13.000J							
SS2-15	TOT ROUND-1	2 29.00003	1710.000	7.5000	<i>4</i> 7.000	<b>2226, 0</b> 00	1348.666	15.00000	55.0000	308.000
597-1 <i>6</i>	TOT ROUND-1	2 17.00003	1520.000	8.0000	74.600	2250,000	1348.000	10.00003	55.0000	265.000
SS2-17	TOT ROUKD-1	13.0000N	76I.000	5.5600	65.000	2355.300	573,600	17.50003	59,0000	588,000
SS2-18	TOT ROUND-1	2 13.0000N	773.060	<b>4.</b> 9000	57.000	1370,000	483,000	4,46003	48, 3060	211,000
SS2-18A	TOT ROUND-:	2	12.0003							
5S2-1BB	TOT ROUND-	2	14.8050							

## SURFICIAL SOIL SAMPLES (METALS)-ASARCD

			Antimony	Arsenic	Cadnius	Chromium	Copper	Lead	Mercury	Nickel	linc
Sta Id	Ani 1	Event	pp <b>a</b>	рра	aqq a	e 4 d	ppa	pp∌	ppb	maqq 	aqq
SS2-18C	TOT	ROUND-2		25.000J							
SS2-19	TOT	ROUND-2	43.0000N	1B40.000	B.5000	54.000	2600.000	1075.000	18.0000J	40,0000	320.000
SS2-20	TOT	ROUND-2	15.00000	1640.000	5.3000	50.000	1178.000	1085.000	12.0000J	43.0000	253,000
SS2-21	TOT	ROUND-2	110.0000J	3700.000	13.0000	60.000	5300.000	3900.000	34.00003	63.0000	618.000
SS2-21A	TOT	ROUND-2		2263.000J							
SS2-21B	TOT	ROUND-2		1060.0003							
SS2-21C	TOT	ROUND-2		15B.000J							
552-22	TOT	ROUND-2	86.0000J	3425.000	8.8000	50.000	2223.000	224B.000	24.0000J	45.0000	453.000
SS2-23	TOT	ROUND-2	17.0000J	1195.000	4.8000	48.000	1060.000	1040.000	10.0000J	32.0000	201.000
552-24	101	ROUND-2	49.0000J	2455.000	8.3000	100.000	2700.000	1790.000	27.0000J	69.0000	393.000
SS2-24A	TOT	ROUND-2		1195.000J							
SS2-24B	101	ROUND-2		60.0003							
SS2-24C	TOT	ROUND-2		12.0003							
5\$2-25	TOT	ROUND-2	13.0000N	145.000	4.5000	50.000	1043.000	348.000	17.0000J	42.0000	159.000
552-26	TOT	ROUND-2	13.0000N	1415.000	6.5000	<b>62.000</b>	2048.000	1130.000	4.4000J	50.0000	245.000
SS2-27	TOT	ROUND-2	15.0000J	1818.000	6.0000	6B.000	2240.000	1433.000	12.0000J	57.0000	328.000

Sta Id	Anl Event	Arsenic ppm	Cadai ua ppa	Chrosium pps	Copper.	Lead ppa	Mercury ppb	Selenius pps	Silver pps	Zinc ppm	Barium ppa	Кą
					FF		FF-				FF	
SS2-01	EPT ROUND-2	0.530	0.0200(	0,042	1.600	0.020<	0.5000N	0.08301	0.00800	0.310	0.50<	4.7
\$52-02	EPT ROUND-2	0.280	0.0220	0.033(	7.400	0.045	0.5000N	0.0B30N	0.0080<	0.510	0.50<	5.4
SS2-03	EPT ROUND-2	0.093	0.0200(	0.033	1.400	0.032	0.5000N	0.0830<	0.0680<	0.160	0.564	5.7
SS2-04	EPT ROUND-2	0.250	0.0720	0.033<	104.000	0.600	0.50004	0.0830(	0.00804	1.600	0.5:	7.8
SS2-05	EPT ROUND-2	0.058	0.0230	0.033<	9.100	0.045	0.5000N	0.0B30<	0.00800	0.430	0.50<	5. <del>9</del>
SS2-0 <i>E</i>	EPT KOUND-2	1.500	0.0200(	0.0334	1.100	0.020(	0.5000N	0.0830<	0.0080(	0.250	0.50<	5.2
SS2-07	EPT ROUND-2	1.100	0.0200<	0.033(	1.200	0.032	0.5000N	0.0830<	0.0080(	0.270	0.50(	5.0
SS2-08	EPT ROUND-2	0.390	0.02004	0.0334	0.390	0.085	0.5000%	0.0B30{	0.0080(	0.240	0.50(	4.6
SS2-09	EPT ROUND-2	0.820	0.02004	0.033<	0.700	0.072	0.5000N	0.0830<	0.00804	0.260	0.50<	4.4
SS2-10	EPT ROUND-2	0.033	0.02004	0.033(	0.540	0.058	0.500CN	0.0830<	0.0030(	0.088	0.50<	4.6
SS2-11	EPT ROUND-2	0.600	0.0200{	0.033<	0.820	0.072	0.5000N	0.0830<	0.00800	0.073	0.50{	4.3
SS2-12	EPT ROUND-2	0.350	0.0200	0.0334	0.580	0.045	0.50con	0.0B30<	0.0080<	0.035	0.500	4.4
SS2-13	EPT ROUND-2	0.320	0.0206<	0.033(	0.886	0.190	0.500GN	0.08304	0.00864	0.120	0.50<	4.4
SS2-14	EPT ROUND-2	0.063	0.02004	0.0334	0.680	0.058	0.500cm	0.08304	0.0080(	0.080	0.504	4.5
SS2-15	EPT ROUND-2	0.170	0.0200<	0.0334	0.980	0.072	0.50000	û,ûB3CN	0.0080(	0.110	0.50<	3.9
SS2-16	EPT ROUND-2	0.350	0.02004	0.033(	0.590	0.032	0.5000N	0.0830(	0.00804	0.047	0.50(	4.2
SS2-17	EFT ROUKD-2	0.320	0.02004	0.033(	0.660	0.020(	0.5000N	0.0830<	0.00800	0.140	0.50(	4.B
592-18	EPT ROUND-2	0.170	0.02000	0.033(	0.150	0.026(	0.5000N	0,08366	0.00800	0.038	0.50<	4.6
SS2-19	EPT ROUND-2	0.390	0.02004	0.033(	0.560	0.05B	0.5000N	0.08064	0.00800	0.047	0.50	4.3
SS2-20	EFT ROUND-2	0.072	0.02004	0.0334	0.790	0.085	0.5000N	0.08300	0.00804	0.047	0.500	4.2
S\$2-21	EFT ROUND-2	ű. 46ù	0.0200(	0.033(	1.500	6.140	0.5000N	0.0830(	0.0080(	0.083	0.564	3.9
SS7-22	EPT ROUND-2	0.160	0.02000	0.033	0.940	0.110	0.5000N	0.1500J	0.00800	0.047	0.504	3.8
352-23	EPT ROUND-2	0.250	0.02000	0.0334	0.580	0.085	0.5000N	0.0B30(	3.00B0K	0.033	0.504	3.8
552-24	EPT ROUND-2	0.53)	0.0200(	0.03%	0.990	0.058	0.5600N	0.0830(	0.0086(	0.130	0.50(	4.1
992-25	EFT ROUND-2	0.600	0.02000	0.033(	0.400	0.020(	n.5000N	0.0830(	0.0080(	0.040	0.500	4,4
SS2-26	EFT ROUND-2	0.250	0.02000	0.937(	0.520	0.032	V0605.0	0.66367	0.00800	0.130	0.504	5.4
SS2-27	EFT FOUND-2	0.170	0.02000	0.033:	6.840	0.072	0.56000	550.083%	0.00867	0.100	0.504	4.2

SUILS QUALITY DATA - ASARCO RI/FS

Sta Id	Anl	Event	Ace naphthene ppb	Acenaph thylene ppb	Aniline ppb	Anthracne pab	Benzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Benzo(b) fluor anthene ppb	Benzo (g,h,i) perylene ppb	Benzo(k) fluor fluor ppb	Benzyl Alcahal ppb	bis(2-chl oroathoxy )methane ppb
METHOD-2	TOT	ROUND-1	330.00<	330.004	330.00<	330.004	2700.004	330.00(	330.00(	330.00<	330.004	330.004	330.00(	330.60(
METHOD-3	TOT	ROUND-1	330.004	330.00(	330.004	330.00{	2700.00(	330.004	330.00(	330.00(	330.00(	330.00<	330.004	330.00(
HETHOD-4	TOT	ROUND-1	330.004	330.00(	330.004	330.00<	2700.00<	330.000	330.00(	330.00(	330.00(	330.00(	330.004	330.00<
METHOD-5	TOT	ROUND-1	330.00<	330.00<	330.004	330.00<	2700.00<	330.00(	330.00<	330.000	330.00<	330.000	330.00(	330.004
METHOD-6	TOT	ROUND-1	330.004	330.004	330.00(	330.00(	2700.00{	330.000	330.004	330.00{	330.00(	330.00(	330.00{	330.0Ó(
MTRXSP-1	TOT	ROUND-1	1660.00	330.00<	330.00(	330.00<	2700.004	330.00(	330.000	330.004	330.004	330.000	330.004	330.000
HTRXSP-2	TOT	ROUND-1	1400.00	330.00(	330.000	330.004	2700.004	330.000	330.00<	330.00(	330.000	330.00(	330.00(	330.00<
SS-01	TOT	ROUND-1	400.00<	400.004	400.00(	4210.00	3000.000	10100.00	9300.00	13000.00	3430.00	400.004	400.004	400.000
SS-02	TOT	ROUND-1	400.00<	400.00<	400.000	17800.00	3000.000	32900.00	30900.00	39700.00	12600.00	400.00{	400.00(	400.000
55-03	TOT	ROUND-1	300.00<	300.004	300.004	300.00(	3000.004	300.004	300.004	300.000	300.004	300.604	300.00{	300.00<
55-04	TOT	ROUND-1	300.00{	300.00<	300.00<	300.00<	3000.000	300.004	300.00{	300.00<	300.00<	300.00<	300.00<	300.00<
55-06	TOT	ROUND-1	400.00<	400.00<	400.004	400.00{	3000.004	400.00N	400.00(	400.004	400.00{	400.00<	400.00<	400.0 <b>0</b> <
55-06-MS	TOT	ROUND-1	1510.00	330.00<	330.000	330.00<	2700.00(	330.00<	330.00<	330.00(	330.00(	330.004	330.00{	330.000
G3M40-2 <b>2</b>	TOT	ROUND-1	1500.00	330.004	330.000	330.00<	2700.00<	330.00(	330.00(	330.00<	330.004	330.000	330.00{	330.000
SS-08	TOT	ROUND-1	500.00<	500.004	500.004	500.00<	4000.00<	500.00(	500.00(	500.000	500.0 <b>0</b> {	500.00(	500.004	500.004
S5-09A	TOT	ROUND-1	500.00<	500.004	500.000	500.004	4000.004	500.600	500.00<	500.00<	500.00(	500.000	500.004	500.000
SS-09B	TOT	RGUND-1	500.00<	500.00<	500.00(	500.004	4000.00<	500.004	500.004	500.0 <b>0</b> <	500 <b>.00</b> <	500.064	500.004	500.000
55-10	TOT	ROUND-1	2550.00	400.004	400.004	3970.00	3000.000	10900.00	10000.00	14200.00	4100.00	460.00(	400.004	400.604
SS-11	TOT	ROUND-1	400.00<	400.004	400.00<	400.000	3000.000	400.00<	400.00<	400.004	400.00(	400.004	400.064	400.000
55-11-MS	TOT	ROUND-1	1500.00	330.004	330.004	330.00<	2700.00(	330.00€	330.00<	330.000	330.00<	330.000	330.000	330.000
SS-11MSD	TOT	ROUND-1	1600.00	330.00<	330.00<	330.00(	2700.00	630.00	430.00	930.00	330.00(	330.00(	330.00(	330.00<
SS-12	101	ROUND-1	400.00<	400,000	400.000	400.00	3000.000	400.000	400.004	490.00	400.00{	400.004	400.884	400.000
SS-13	181	ROUND-1	40ú.00{	400.00<	<b>400.</b> 00(	400.000	3000.00<	430.00	400.000	790.00	400.004	400.000	400.00(	400.00<
55-16	TOT	ROUND-1	500.00(	500.000	500.00(	500.00(	4000.00<	720.00	500.00	960.00	500.004	500.000	500.00(	500.000
SS-19	TOT	ROUND-1	400.004	400.00(	400.004	400.00<	3000.00	400.000	400.00N	400.0 <b>0</b> N	400.00N	400.00N	400.004	400.00(
58-20	101	ROUND-1	2100.00	2000.000	2000.000	4400.00	20000.000	7500.00	5600.003	4400.00J	2000.00N	2000.GON	2000.000	2000.000
58-21		เ คิดีบทติ-1	20000.003	20000.00R	20000.00%	40000.00J	200000.009	108000.GGJ	72000.003	80000.00J	48000.00J	20000.00R	20000.00E	20000.00R
SS-22	101	round-1	400.000	2000.004	2000.000	1350.00	3000.000	4350.00	3730.00	400.000	2160.00	2960.00	2000.004	2000.0 <b>0</b> <
55-23	TOT	F-ROUND-1	<b>2000.</b> 06(	2000.004	2000.004	2000.000	20000.00<	2000.000	2000.00(	2000.00(	2000.004	2000.00N	2000.000	2000.00(
59-24	TO	ROUND-1	400.00<	400.00(	400.00(	400.00<	3000.00<	400,007	400.000	400.000	400.004	400.0GN	400.004	400.000
<b>SS-2</b> 5	TOT	ROUND-1	400.004	400.00(	400.000	400.004	3000.000	400.000	400.00<	400.000	400.00<	400.00N	400.000	460.004
55-28	701	F ROUND-1	400.000	400.004	400.000	610.00	3000.000	2100.00	1670.00	3390.00	1300.00	400.00N	400.000	400.004

BOILS QUALITY DATA - ASARCO RI/FS

Sta Id	Ani	Event	bis(2-chl oroethyl) ether pab	bis(2-chl oroisopro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Bromooh enyl-phen yl ether ppb	Butyl benzyl phthalate ppb	4-Chloro aniline ppb	2-Chloro maphthlme ppb	4-Chlorup heayl phe byl ether ppb	Ct:rysene ppb	Dibenzo (a <sub>1</sub> h) anthracne ppb	Bibenzo furan ppb	1,2- Diclora benzene ppb
METHOD-2	101	ROUND-1	330.00(	330.00(	330.000	330.00(	330.00(	330.00(	330.00(	330.00(	330.06(	330.00<	330.00(	330.00(
METHOD-3			330.000	330.00<	330.000	330,000	330.000	330.00<	330.004	330.000	330.004	330.000	330.00(	330,000
METHOD-4			330.00<	330.00(	330.000	330.00(	330.000	330.00(	330.004	330.00<	330.00<	330.004	330.004	330.000
METHOD-5	TOT	ROUND-1	330.60(	330.000	330.00<	330.000	330.00<	330.004	330.00<	330.000	330.000	330.064	330.000	330.000
METHOD-6			330,000	330.00(	330.00<	330.004	330.00<	330.000	330.000	330.000	330.00{	330.000	330.004	330,000
MTRXSP-1			330.000	330.000	330.004	330.000	330.00(	330.000	330.000	330.000	330.000	330.00(	330.000	330.000
NTRXSP-2			330.000	330.000	430.0 <b>0</b>	330.900	330.004	330.000	330.066	330.00(	330.000	330.00(	330.000	330.000
SS-01	TOT	ROUND-1	400.004	400.0 <b>0</b> 0	400.00{	400.004	460,000	400.004	400.004	400.000	12100.00	490.00	1500.00	400.000
SS-02	101	ROUND-1	400.00<	400.004	400.00<	400.004	400.00(	400.00(	400.00	400.000	36500.00	2860.00	7200.00	400.000
SS-03	TOT	ROUND-1	300.000	300.004	300.00k	360.00<	300.00(	300.000	300.000	300.000	520.00	300.004	300.000	300.00(
SS-04	TOT	ROUND-1	300.004	300.000	300.000	300.000	300.000	300.00/	300.00(	300.004	300.00(	300.000	300.000	300.000
55-06	TOT	ROUND-1	400.00<	400.00<	400.00N	400.00(	400.00N	400.000	400.000	400.000	400.0QN	400.000	400.00K	400.000
SS-04-MS	TOT	ROUND-1	330.00<	330.00(	790.00	330.000	330.000	330.004	330.000	330.000	330.00(	330.00(	330.604	330.000
SS-04MSD	TOT	ROUND-1	330.00{	330.00(	330.00(	330,000	330.000	330.00(	330.00<	330.000	330.000	330.000	330.000	330.000
\$5-0B	TOT	ROUND-1	500.000	500.000	500.000	500.0 <b>0</b> K	500.064	500.000	560.00(	500.0 <b>0</b> <	500.000	500.004	500.000	500,000
SS-09A	TOT	ROUND-1	500.004	500.000	500.00(	500.00(	500.000	500.600	500.000	500.000	300.004	500.00{	500.030	500.004
SS-09E	101	RDUND-1	500.00(	500.000	500.000	500.000	500.00(	500.000	500.004	500.00<	500.00(	500.000	560.000	500.000
SS-10	TOT	ROUND-1	400.00(	400.000	430.000	400.000	400.004	400.00	400.000	400.000	13360.00	920.00	1906.00	400.000
55-11	101	ROUND-1	400.00{	400.004	430.000	400.00(	400.004	400.007	400.00<	400.000	400.004	400.600	400.000	400.000
SS-11-NS	TOT	ROUND-1	330.064	330.004	330.60k	330.00(	330.000	336.000	336.004	336.000	330.000	330.000	330.000	330.000
95-11M50	157	ROUNE-1	330.000	330.0 <b>0</b> (	330.600	330.000	330.000	336.000	330.000	330 <b>.0</b> 00	530.00	330.00{	330.000	333.000
55-17	TOT	ROUND-1	400.0 <b>0</b> (	400.00(	400.00(	400.060	400.000	400.000	400.000	400.000	450.00	400.000	400.00(	460.000
59-13	TOT	ROUND-1	400.000	460.00(	460.664	400.664	400.004	400.000	400.000	400.000	550.00	400.000	400,000	400.000
SS-16	101	ROUND-1	500.0 <b>6</b> K	500.00(	500.004	500.000	500.000	500.000	500.00<	500.000	1610.00	500.00(	560.000	500.000
SS-17	101	ROUND-1	400.00<	400.00(	430.30	400.000	<b>46</b> 0.00<	460.000	400.000	(00,00)	400.00<	400.00N	400.000	400.030
SS-20	101	R0540-1	2000.000	2000.064	2000.00N	2600.000	2000.50N	2600.304	2006.060	2000.004	8300.0 <b>0J</b>	2000.00N	1300.000	2000.000
59-21	TOT	ROUND-1	20000.00A	20000.008	20000.605	20000.00R	20000.308	10005.00R	20000-008	20000.00R	112000.063	20000.00%	20000.00R	20000.00R
SS-22	101	R0UND-1	2000.000	2000.000	400.000	400.000	400.000	2000.00.	2600.000	460.000	5260.00	400.000	400.000	2000.050
SS-23	TOT	ROLXD-1	2066.000	2000.000	2000.000	2000.004	2000.00	2000.000	2000.000	2000,000	2060.600	2000.004	2000.000	2000.000
SS-24	101	ROUND-1	400.00{	400.000	400.06:	400.000	400.000	400.00.	400.00/	400.600	400,000	400.00(	400.000	400.000
55-25	TOT	FOUND-1	400.000	400.000	460.00<	400.000	490.000	400.00	400.000	400.000	406.604	400.06<	469.004	400,000
53-26	TüT	ROUND-1	400.000	400.000	400.000	400.000	400.000	400.004	403.064	4 <b>0</b> 0.004	2330.00	400.000	400.00(	400.000

SURFICIAL SCILS - ASARCO (BASE NEUTRALS)

Sta Id	Anl Event	1,3- Dichloro benzene ppb	1,4- Dichloro benzene ppb	3,3'- Dichloro benzidine ppb	Diethyl phthalate ppb	Dimethyl phthalate ppb	Di-a- Butyl phthalate ppb	2,4- Dinitro toluene ppb	2,6- Dinitro toluene ppb	Di-n- Octyl Phthalate ppb	Fluor anthene ppb	Fluorene ppb	Hexa chloro benzene ppb
METHOD-2	TOT ROUND-	1 330.004	330.00(	670.000	330.00(	330.004	330.004	330.004	330.00<	330.004	330.00(	330.00(	330,000
	TOT ROUND-		330.000	670.004	330.00(	330.00(	330.000	330.00<	330.000	330.004	330.000	330.064	330.000
	TOT ROUND-		330.00(	670.004	330.004	330.004	330.000	330.000	330.000	330.004	330.00(	330.000	330.000
	TOT ROUND-		330.00(	670.004	330.000	330.00<	330.000	330.060	330.000	330.004	330.00(	339.004	330,000
	TOT ROUND-		330.004	670.000	330.000	330.00<	330.000	330.000	330.000	330.000	330.000	339.000	330.000
MTRXSP-1	TOT ROUND-	1 330.004	1600.00	670.000	330.000	330.004	330.000	1600.00	330.000	330.00(	370.00	330.00<	330.000
NTRXSP-2	TOT ROUND-	1 330.004	1360.00	00.044	330,004	330.00<	330.00<	1330.00	330.0 <b>0</b> <	330.004	330.000	330.00(	330.000
SS-01	TOT ROUND-	1 400.004	400.004	B00.00K	400.004	400.004	400.004	400.004	400.004	400.004	21500.00	2710.66	400.000
59-02	TOT ROUND-	1 400.000	400.000	800.004	400.600	400.00	400.000	460.004	400.000	400.004	75300.00	10300.00	400.004
SS-03	TOT ROUND-	1 300.004	300.00<	700.000	300.00(	300.00(	300.00(	300.000	300.000	300.000	970.00	300,000	300.000
55-04	TOT ROUND-	1 300.004	300.000	700.004	300.00<	300.000	300.000	300.00<	360.000	300.00<	300.004	300.000	300.00(
55-06	TOT ROUND-	1 400.004	400.00(	BOO.OON	400.000	400.000	400.000	400.000	400.000	400.004	400.004	400.000	400.004
SS-06-MS	TOT ROUND-	1 330.004	1350.00	A60.00K	330,004	330.00<	330.00(	1450.00	330.00<	330.004	330.00(	330.004	330.000
SS-OEMSD	TOT ROUND-	1 330.004	1190.00	460.000	330.004	330.004	330.000	1330.00	330.000	330.00(	330.004	330.000	330.00(
55-08	TOT ROUND-	1 500.004	500.000	1000.000	500.004	500.004	<b>500.</b> 000	500.004	500.600	500.004	500.000	<b>5</b> 00.000	500.004
ES-C9A	TOT ROUND-	1 500.004	500.004	900.000	500.00(	500.00{	500.00(	500.004	500.00(	500.004	500.00(	500.000	500.004
SS-09B	TOT ROUND-	1 500.004	590.00<	900.000	500.004	500.000	500.004	500.000	500.00,	500.004	500.000	500.000	5 <b>0</b> 0.000
SS-10	TOT ROUND-	1 400.000	400.004	800.000	400.004	400.004	400.000	400.000	400.000	400.004	24600.00	3090.00	400.004
55-11	TOT ROUND-	1 400.004	400.00<	300.00€	460.00(	400.00<	400.000	400.004	400.060	400.004	400.000	400.004	400.000
55-11-KS	TOT ROUND-	1 330.004	1330.00	670.004	330.000	330.060	336.06(	1300.00	330.00<	330.00<	330.00<	330.000	330.004
SS-11MSD	TOT ROUND-	330.004	1300.00	<b>670.00</b> (	330.000	330.000	330.000	1430.00	330.000	330.000	1430.00	330.000	330.004
55-12	TOT ROUND-	1 400.004	400.000	B00.00(	400.064	400.000	400.00<	400.004	400.000	400.600	400.000	400.064	400.064
55-13	TOT KOUMB-	1 400.004	400.004	B00.00K	400.00%	400.000	400.000	400.004	460.000	400.00<	990.00	400.000	400.000
55-16	TOT ROUND-	1 500.004	500.004	900.00(	500.000	500.004	<b>50</b> 0.09(	500.000	500.000	500.004	1310.00	500.000	500.000
SS-19	TOT ROUND-	1 400.004	400.060	<b>8</b> 00.000	400.000	400.000	460.00<	400.000	400.000	400.00N	400.000	400.00(	400.000
SS-20	TOT ROUND-	1 2000.004	2000.000	4000.00N	2000.004	2000.00(	2000.000	2000.000	2000.000	2000.00N	11100.00	3000.00	2000.000
55-21	TOT ROUND-	1 20000.00R	20000.00R	40030.00R	20000.00R	20000.00R	20000.00R	20000.00%	20000.00R	20000.00R	169000.003	31000.00J	20000,00R
\$5-22	TOT REUND-	1 2000.000	2000.000	700.000	400.004	2000.000	400.000	400.000	400.000	400.004	6730.00	400.00(	400.000
\$9-23	TOT ROUND-	1 2000.004	2000.004	4000.000	2000.000	2000.000	2006.004	2000.000	2000.000	2600.000	2000.000	2000.004	2006.004
SS-24	TOT ECUND-	1 400.004	400.000	700.004	i00.00{	460.004	400.000	400.000	400.000	400.000	400.000	400.000	400.000
SS-25	TOT ROUND-	1 400.06<	466.664	806.000	400.000	400.30(	400,000	400.000	400.000	400.004	540.00	400.600	400.000
55-25	TOT ROUND-	1 400.000	400.000	800.000	400.000	<b>40</b> 0.000	400.000	400.004	400.000	400.00(	3620.00	400.000	400.004

## SURFICIAL SOILS - ASARCO (BASE NEUTRALS)

Sta Id	Anl	Event	Hexa chloro butadiene ppb	Hexachlor ocyclopen tadiene ppb	Hexa chloro ethane ppb	Indeno (1,2,3-cd Pyrene ppb	Iso pharone ppb	2-Methyl naphtnine ppb	Naphthlne ppb	2-Nitro aniline ppb	3-Nitro aniline ppb	4-Nitro aniline ppb	Nitro benzene ppb	M-Mitroso dimethyl amine ppb
HETHOD-2	TOT	FOUND-1	330.00(	330.00(	330.004	330.00(	330.00<	330.00<	330.00(	1700.00<	1700.00<	1700.00(	330.00(	330,000
METHOD-3			330.00(	330.00(	330.004	330.00<	330.00	330.00(	330.000	1700.000	1700.000	1700.000	330.00(	330.000
METHOD-4			330.00(	330.004	330.004	330.00(	330.004	330.00(	330.00(	1700.000	1700.000	1700.000	330.00(	330.000
METHOD-5			330.00(	330.00(	330.004	330.004	330.004	330.00<	330.004	1700.000	1700.000	1700.000	330.00(	330.004
METHOD-6			330.00(	330.00<	330.000	330.00(	330.00(	330.00(	330.00K	1700.00(	1700.000	1700.000	330.00(	330.00K
HTRXSP-1			330.00<	330.00<	330.004	330.004	330.000	330.000	330.000	1700.000	1700.000	1700.00	330.000	330.000
HTRISP-2			330.00<	330.000	330.00(	330.00<	330.004	330.00(	330.60(	1700.000	1700.000	1700.004	330.004	330.00(
55-01		ROUND-1	400.000	400.004	400.004	400.004	400.000	1960.00	3070.00	2000.000	2390.00	2000.00{	400.000	400.00K
SS-02		ROUND-1	400.004	400.004	400.064	12600.00	400.00	4800.00	16200.00	2000.004	11900.00	2600.00(	400.004	400.004
55-03		ROUND-1	300.004	300.004	300.004	300.00{	300.004	300.000	300.000	2000.000	2000.00(	2000.00(	300.604	300.000
S5-04		ROUND-1	300.000	300.00(	300.000	300.00(	300.000	300.06(	300.004	2000.00(	2000.000	2000.00{	309.00<	300.000
SS-06		ROUND-1	400.004	400.000	400.004	460.000	400.00:	400.000	400.000	2000.000	2000.000	2000.000	400.004	400.004
55-06-MS			330.00(	330.004	330.00<	330.004	330.00<	330.00(	330.000	1700.00(	1700.000	1700.004	330.004	330.000
SS-06MSD			330.00(	330.004	330.000	330.064	330.00(	330.004	330.004	1700.004	1700.004	1700.000	330.000	336.000
55-08		ROUND-1	500.004	500.00(	500.000	500.00<	500.000	500.000	500.004	3000.000	3000.000	3000.004	500.00(	500.000
55-09A		ROUND-1	500.004	500.000	500.004	500.000	500.000	500.00	500.000	2000.000	2000.000	2000.000	500.000	500.000
SS-098		ROUND-1	500.00(	500.00(	500.000	500.000	500.000	500.000	500.00(	2000.000	2000.004	2000.000	500,000	5000.000
\$5-10		ROUND-1	400.004	400.00(	400.004	3880.00	460.00<	2100.00	5010.00	2000.000	2000.004	2000.000	409.000	400.004
55-11		ROUND - 1	400.004	400.00<	460.00(	400.00(	400.000	460.096	466.00<	2000.000	2000.004	2000.000	<b>40</b> 0.000	460.00(
SS-11-NS	101	ROUND-1	330.000	330.000	330.000	330.000	330.000	330.000	330.000	1700.000	1700.000	1700.004	330.060	330.00<
SS-11MSE	161	ROUND-1	330.06<	330.00<	330.664	370.00	330.00€	330.004	339.00(	1700.000	1700.004	1700.000	330.000	330.000
55-12	TOT	ROUND-1	400,000	400.00	400.000	400.000	400.000	400.000	400.060	2000.000	2000.00(	2000.000	400.000	400.000
55-13	101	ROUNS-1	400.00<	400.00<	400.00%	400.000	400.000	400.00	400.300	2600.000	2000.004	2000.000	400.000	400.00<
55-16	763	ROUNG-1	500.004	500.000	500.000	500.000	500.000	500.00:	500.96K	2000.00(	2000.000	2000.000	500.001	500.00(
55-19	101	ROUND-1	400.000	400.004	400.060	400.00m	400.000	460.000	400.000	2000.060	2000.000	2000.000	460.064	460.000
SS-20	101	ROUND-1	2000.000	2000.00(	2000.000	2000.00N	2000.000	2000.000	2000.000	10000.000	10000.000	10000.000	2000.000	2000.000
55-21	TOT	ROUND-1	20000.00R	20000.008	20000.008	39000.000	20000.00A	3.000.003	19000.001	100000.008	1600 <b>0</b> 0.00 <b>R</b>	10000C.00R	20000.00R	20000.00 <b>R</b>
55-22	Tet	ROUND-1	20 <b>0</b> 0.00K	20 <b>0</b> 0.000	2000.000	400.000	2000.00<	2600.06%	2000.004	9000.000	26 <b>0</b> 0.064	2000.007	2000.000	2000.0 <b>0</b> 0
55-23		RGUND-1	2000.000	2000.000	2000.000	2000.090	2000.000	2000.000	20 <b>9</b> 0.0 <b>0</b> √	9000.000	9000.000	9000.001	2600.000	2006.00(
SS-24		ROUND-1	<b>40</b> 0.000	400.000	400.000	400.30(	400.000	400.007	400.00(	2000.000	7000.000	2000.001	400.000	400.000
56-25	101	ROUND-1	<b>4</b> 00.0 <b>0</b> 4	<b>46</b> 0.00<	400.064	460.000	400.000	106.06	400.00(	2000.000	2000.000	2000.000	400.000	400,000
SS-2&	707	ROUND-1	400.000	400.0 <b>0</b> 0	400.000	1939.00	400.000	400.000	400.000	2000.000	2000.000	2000.000	400.00	400.000

Staid Ar	ol Event	N-Nitroso dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Phen anthrene ppb	Pyrene ppb	1.2,4-Tri chloro benzene ppb	PCBs ppb
METHOD-2 TO	DT ROUND-1	330.004	330.00(	330.064	330.000	330.00<	1000.000
METHOD-3 TO		330.004	330.004	330.004	330.000	330.000	200.000
NETHOD-4 TO	DT ROUND-1	330.00<	330.00<	330.004	330,000	330.00<	200.000
METHOD-5 TO	OT ROUND-1	330.00<	330.00{	330.004	330.000	330.004	1000.00(
METHOD-6 TO	DT ROUND-1	330.00{	330.064	330.000	330.000	330.00(	1000.000
MTRXSP-1 TO	BT ROUND-1	1400.00	330.004	430.00	2330.00	1700.00	11200.00
MTRXSP-2 TO	OT ROUND-1	1160.00	330.00<	330.00(	1630.00	1400.00	9100.00
SS-01 T	OT ROUND-1	400.004	400.004	24600.00	30000.00J	400.000	1000.00N
5S-62 T	OT ROUND-1	400.00<	400.00<	71400.00	79300.00J	400.00	1000.00N
SS-03 T	OT ROUND-1	300.00<	300.00<	300.004	B40.00	300.00<	1000.00N
SS-64 T	OT ROUND-1	300.004	300.00<	300.000	300.004	300.004	1000.00N
55-06 TI	DT ROUND-1	400.00<	400.00<	400.000	400.00N	400.00<	1000.00N
55-06-HS TI	OT ROUND-1	1030.00	330.004	330.00(	1870.00	1360.00	9900.00
SS-CANSD TO	OT ROUND-1	980.00	330.00<	330.00<	1990.60	1280.00	10100.00
55-08 T	OT ROUND-1	500.00<	500.00(	500.00(	500.004	500.00(	2000.00N
SS-09A T	BT ROUND-1	500.00(	500.004	500.00<	500,000	500.000	1000.00M
55-09B T	OT ROUND-1	500.00<	500.000	500.064	500.0 <b>0</b> <	500.00<	1000.00N
SS-10 T	OT ROUND-1	400.00<	400.00<	28000.00	29600.00J	400.00<	2510.00J
55-11 T	OT ROUND-1	400.00<	400.060	400.00	400.00<	400.004	1000.00N
SS-11-MS T	DT ROUND-1	1160.00	330.004	330.00(	2000.00	1560.00	11000.00
SS-11MSD T	DT ROUND-1	1100.00	330.00<	2000.00	3660.00	1630.00	10800.00
55-12 T	GT ROUND-1	400.004	400.000	490.00	490.00J	400.004	1000.00N
55-13 T	OT ROUND-1	400.004	400.000	990.00	1230.00	400.000	1000.00N
1 61-22	GT ROUND-1	500.00{	500.00(	1420.00	1570.00	500.000	K00.0001
55-19 T	OT ROUND-1	400.00<	400.00<	400.000	590.00	400.00(	1000.00N
SS-20 T	OT ROUND-1	2000.004	2000.004	20300.00	26400.00J	2000.000	2930.003
SS-21 T	OT ROUND-1	· 20000.00R	20000.00R	265000.00J	277000.00J	- 20000.GOR	1000.00N
SS-22 T	OT ROUND-1	2000.000	400.00<	7420.00	16700.00	2000.00(	1000.00%
55-23 1	OT ROUND-1	2000.000	2000.000	2000.00(	20 <b>0</b> 0.00(	2060.000	1000.004
	OT ROUND-1	400.060	400.00(	400.604	400.000	400.004	1000,00%
SS-25 T	OT ROUND-1	400.00<	400.000	560.00	580.00	400.000	1000.00M
55-26 T	TOT REUND-1	400.00<	400.064	3399.00	4580.00	400.000	1000.96%
55-27 T	TOT ROUND-1	2009.004	2000.000	3400.00	4400.60	2000.000	1600.06%

SDILS QUALITY SATA - ASARCO RI/FS

Sta Id	Asil	Event	Benzoic Acid ppb	2-Chloro phenol ppb	2.4-Di chloro phenol ppb	2,4-Bi methyl phenal ppo	2,4-Di nitro phanol ppb	2-Methyl phenal ppb	4-Methyl phenol ppb
METHOD-2	TOT	RDUND-1	1700.004	330.00(	330.004	330.00(	1700.004	3 <b>30.</b> 004	330.00<
HETHOD-3			1700.000	330.000	330.064	330.000	1700.00<	330.004	330.000
METHOD-4			1700.004	330.00(	330.004	330.00(	1700.004	330,000	330.00<
METHOD-5			1700.004	330.000	330.060	330.064	1700.000	330.000	330.000
HETHOD-6			1700.004	336.064	330.004	330.00(	1700.004	330.004	330.000
MTRXSP-1			1700.004	3130.00	330,000	330.066	1700.000	330.000	330.000
MTRXSP-2			1700.004	2730.00	330.00(	330.00(	1700.000	330.00(	330.000
SS-01		ROUND-1	2000.004	400.000	460.00(	400.000	2000.000	400.000	400.000
SS-02		ROUND-1	2000.000	400.004	400.004	400.000	2000.000	400.064	400.000
SS-03		ROUND-1	2000.000	300.00(	300.000	300.00(	2000.000	300.000	300,000
SS-04		ROUND-1	2000.000	300,000	300.000	300.00(	2000.000	300.000	300.000
SS-0Ł		ROUND-1	2000.000	400.004	400.004	400.000	2000.00	400.000	400.064
55-06-HS			1700.004	2500.00	330.004	330.004	1700.000	330.000	330.004
SS-OAKSD			1700.000	2290.00	330.000	336.000	1700.000	330.000	336.000
SS-08	101	ROUND-1	3000.000	500.000	500.00{	500.000	3000.000	500.00(	500.004
SS-09A	TOT	RDCAD-1	2000.000	500.00(	500.000	500.000	2000.00<	500.000	500.000
SS-09B	TOT	ROUND-1	2000.004	500.000	500.00(	500.00(	2000.004	<b>500.0</b> 0%	500.000
SS-10	TCT	ROUND-1	2000.004	400.000	400.000	400.00(	2000.000	400.000	400.000
SS-11	TOT	ROUND-1	2000.0 <b>0</b> K	400.000	409.004	400.000	2000.000	400.00:	400.064
SS-11-MS	TOT	ROUND-1	1700.000	2430.00	330.004	330.000	1700.000	330.000	330.000
SS-11MSD	TOT	ROUND-1	1700.000	2300.00	330.000	330.00(	1706.000	330.000	330.000
SS-12	TOT	ROOMB-1	2000.000	400.00<	400.000	400.000	2000.000	460.000	400.004
59-13	TOT	ROUND-1	2000.064	400.004	400.000	400.000	2000.000	400.000	400.000
59-16	Tül	ROUND-1	2000.00(	500.06K	500.00(	500.00(	2000.000	500.00t	50(.00(
EE-19	TUT	ROUMD-1	2000.004	400.004	460.06:	400.004	2000.000	468,360	406.000
59-20	TOT	ROUND-1	10000.000	2000.000	2000.000	2000.000	19000.000	2000.064	2060.000
55-21	TOT	KOUND-1	100000.00R	20000.00R	20000.00%	20000.00R	100000.00R	20000.06%	20000.00R
SS-22	TOT	ROUND-1	9000.001	2000.000	2009.090	2000.000	2000.000	2000.004	2000.00:
59-23	TüT	FOUNT-1	9000.000	2000.000	2000.550	2000.000	9000.000	2000.065	2000.000
55-24	TOT	1-08/203	2000.064	400.00(	490.000	400.000	2006.000	400.000	400.000
SS-25	TOT	ROUND-1	2000.000	400.004	400.00	400.000	2000.000	460,000	400.000
\$5-26	TOT	ROUND-1	2600.00(	400.004	400.004	400.000	2000.000	4(4),004	460.061

SDILS QUALITY DATA - ASARCO RI/FS

Sta Id	Anl	Event	2-Nitro phenol ppb	4-Nitro phenal ppb	4-Chloro- 3-sethyl phenol ppb	Penta chloro phenol ppb	Phenol ppb	2,4,5-Tri chloro phenol ppb	2,4,6-Tri chloro phenol ppb
METHOD-2	TOT	ROUND-1	330.00<	1700.00<	330.004	1700.004	330.604	1700.00(	330.00(
NETHOD-3			330.00{	1700.004	330.000	1700.004	330.00<	1700.000	330.00(
HETROD-4	TOT	ROUND-1	330.00(	1700.00{	330.004	1700.004	330.00<	1700.004	330.004
METHOD-5	TOT	ROUND-1	330.00(	1700.000	330.00(	1700.00<	330.00<	1700.000	330.004
METHOD-6	TOT	ROUND-1	330.00<	1700.000	330.00(	1700.004	330.00<	1700.00{	330.00(
MTRXSP-1	TOT	ROUND-1	330.004	3330.00	3330.00	3660.00	3660.00	1700.00<	330.00{
HTRXSP-2	TBT	ROUND-1	330.00<	2590.00	2630.00	3220.00	2560.00	1700.004	330.00(
55-01	107	ROUND-1	400.00<	400.000	400.004	2000.004	400.00<	2000.000	400.00<
SS-02	TOT	ROUND-1	400.000	400.004	400.004	2000.000	400.000	2000.000	400.000
55-03	TOT	ROUND-1	300.00<	2000.004	300.000	2000.000	300.000	2000.000	300.00{
SS-04	TOT	ROUND-1	300.00{	2000.000	300.00(	2000.004	3000.000	2000.004	300.000
55-06	TOT	ROUND-1	400.00{	400.00{	400.000	2000.000	400.000	2000.000	400.000
SS-06-MS	TOT	ROUND-1	330.00<	1260.00	2500.00	4320.00	3460.00	1700.00(	330.00K
SS-CAMSD	TOT	ROUND-1	330.00<	1270.00	2410.00	4580.00	- 3140.00	1700.000	330.004
55-08	TOT	ROUND-1	500.00<	3000.004	500.004	3000.000	500.004	3000.004	500.00<
SS-09A	TOT	ROUND-1	500.004	2000.004	500.000	2000.00<	5000.000	2000.000	500.00
5S-09B	TOT	ROUND-1	500.004	2000.004	500.000	2000.000	500.004	2000.00<	500.004
SS-10	TOT	ROUND-1	400.00	400.004	400.034	2000.004	400.00(	2000.000	400.00<
SS-11	TOT	ROUND-1	400.004	400.000	400.004	2000.000	400.000	2000.000	400.004
55-11-MS	TOT	ROUND-1	330.00(	1360.00	2530.00	3490.00	2060.00	1700.000	330.00K
SS-11MSD	TOT	ROUND-1	330.004	1530.00	2600.00	3030.00	2070.00	1700.000	330.000
55-12	TOT	ROUND-1	400.00{	400.00(	400.00<	2900.000	400.000	2000.004	400.00(
55-13	TUT	ROUND-1	400.00(	400.004	400.004	2000.00(	400.000	2000,600	400.00<
55-16	TOT	ROUND-1	500.00(	2000.004	500.000	2300.000	500.004	2006.060	500.00(
53-19	TOT	ROUND-1	400.00<	400.000	400.004	2000.00(	400.000	2000.00(	400.00(
55-20	TOT	ROUND-1	2000.00	10000.000	2000.000	10000.000	2000.00(	10000.004	2000.004
SS-21	TOT	RDUND-1	20000.00R	100000.00R	20000.00R	100000.00R	20000.00R	100000.00R	20000.00R
55-22	TOT	ROUND-1	2000.000	2000.000	2600.004	2000.00(	2000.000	5000.004	2000.00(
SS-23	TOT	ROUND-1	2000.000	9000.604	2000.000	9000.00(	2000.000	9000.000	2000.000
55-24	TOT	ROUND-1	400.00<	400.004	100.00	2000.000	400.000	2000.000	400.036
SS-25	TOT	ROUND-1	400.00<	400.000	400.00(	2000.0 <b>0</b> {	409.000	2000.000	
55-28	TOT	ROUND-1	400.004	400.004	400.000	2000.004	400.00{	2000,06(	400.004

EDILS QUALITY DATA - ASARDO RI/FS

Sta Id	Anl	Event	Benzoic Acid ppb	2-Chloro phenoi ppb	2.4-Di chloro phenol ppb	2,4-Di methyl phenol ppb	2,4-Di nitro phenol ppb	2-Metnyl phenol ρφb	4-Kethyi phenal ppb
SS-27	TOT	ROUND-1	10000.60<	2000.004	2000.00(	2000.004	10000.06(	2000.00(	2000.064
SS-28		ROUND-1	2000.000	400.004	400.000	400.000	2000.000	400.00c	400.000
SS-29		ROUND-1	2000.060	400.000	400.00{	400.000	2000.000	400.000	400.000
88-30		RDUND-1	2000.000	400.000	400.000	400.000	2000.000	<b>40</b> 0.000	400.000
55-31A		ROUND-1	2000.000	400.000	400.004	400.000	2000.000	400.000	400.000
S5-318		ROUND-1	2000.004	400.064	400.000	400.000	2000.000	400.000	400.004
SS-32		ROUND-1	2000.09(	400.000	400.000	400.000	2000.00<	400.000	400.0%
55-33		REUND-1	2000.604	400.000	400.000	400.000	2006.000	400.00	400.000
SS-34		ROUND-1	2000.004	400.000	400.00(	400.000	2000.064	400.064	400.000
SS-35		ROLND-1	2000.000	400.000	400.000	400.000	2000.004	400.000	409.000
55-36		ROUND-1	2300.00	400.000	400.000	400.000	2000,000	400.000	400.004
SS-37		FOUND-1	2000.000	500.000	500.000	500.000	2000,000	500.000	500.004
SS-38		ROUND-1	2000.000	400.000	400.000	400.00	2000,000	400.004	400.000
53-39		ROUND-1	2000.000	400.004	400.000	400.000	2000,000	400.000	400.000
SS-40		ROUND-1	2000.000	400.000	400.000	400,000	2000.000	400.000	400.090
55-41		ROUND-1	2000.000	400.000	400.090	400.000	900.00K	400.000	400.004
55-41-HS			1700.000	1400.00	330.004	330.004	1700.000	330.000	330.00<
55-41MED			1700.000	1230.00	330.000	330.000	1700.004	330.00K	330.000
55-42		ROUND-1	2000.000	400.000	400.000	400.000	2000.004	400.001	400,680
SS-43		RDUND-1	2000.000	400.000	400.000	400.000	2000.000	400.004	400.000
98-44		ROLND-1	2000.000	400.000	400.000	400.000	2000.000	400.000	400.000
SS-45		ROUND-1	2000.000	400.000	400.00<	400.000	2000.00	400.001	400.000
SS-45		EBUND-1	2000.000	400.000	400.000	4(0.004	2000.064	400.600	400.000
SE-47		ROUMB-1	2000.000	400.000	400.004	400.000	2000.000	400.004	400.064
SE-48		REUND-1	2000.03(	400.00(	400.000	400.034	2000.000	450,500	400.00
88-49		REUND-1	2000.001	400.000	400.000	460.004	2000.060	400,000	400.660
39-53		1-00:00	2000.000	400.000	400.00:	400.000	2000.000	40600	400.00
SS-51		ROUND-1	40060.00:	2000.000	£009.00K	5009.004	40000.000	5000.00.	8000.000
\$8-52		ROUND-1	50000.000	7000.00:	9660.00	9000.000	56056,000	9000.760	9956.000
55-53		REUND-1	50000.000	10000.000	100 06,500	10600.000	50400.000	10006.007	10000.000
58-54		03UND-1	F0000.00K	10000.00/	10000.000	10000.000	30000.000	100(0.00)	10000.30:
58~55	101	REUND-1	2000.000	400.00(	400.00%	400.000	2006.500	4(6,01)	400.00

SOILS QUALITY DATA - ASARCO RI/FS

Ph. 11		2-Nitro phenol	4-Nitro phenol	4-Chloro- 3-methyl phenol	Fenta chloro phenol	Phenal .	2,4,5-Tri chloro phenol	2,4,6-Tri chloro phenol
Sta Id	Anl Event	ppb	ppb	ppb	ppb	ppb	ppb 	ppb
SS-27	TOT ROUND	-1 2000.00{	10000.00<	2000.000	10000.000	2000.004	10000.000	2000.004
SS-28	TOT ROUND	-1 400.00<	400.00<	400.00	2000.00<	400.00{	2000.00{	400.00<
SS-29	TOT ROUND	-1 400.00<	400.00<	400.000	2000.00<	400.00	2000.00(	400.00<
55-30	TOT ROUND	-1 400.00<	400.00<	400.00<	2000.00<	400.00<	2000.004	400.00<
SS-31A	TOT ROUND	-1 400.004	400.00{	400.00	2000.00<	400.00(	2000.004	400.004
SS-31B	TOT ROUND		400.00<	400.00<	2000.00<	400.00<	2000.00{	400.00<
55-32	TOT ROUND	-1 400.004	400.00<	400.00<	2000.00<	400.00<	2000.00{	400.004
SS-33	TOT ROUND		400.00<	400.00<	2000.00<	400.000	2000.004	400.00<
SS-34	TOT ROUND	-1 400.004	400.00<	400.00<	2000.00<	400.00<	2000.004	400.004
SS-35	TOT ROUND	-1 400.004	400.00<	400.00<	2000.00<	400.00	2000.00<	400.00<
SS-36	TOT ROUND	-1 400.00<	400.00<	400.00(	2000.000	400.00<	2000.00(	400.00{
SS-37	TOT ROUND	-1 500.00<	2000.004	500.00<	2000.00<	500.00{	2000.00(	500.004
SS-38	TOT ROUND	-1 400.004	400.00<	400.00(	2000.000	400.00<	2000.00(	400.004
55-39	TOT ROUND		400.00<	400.00(	2000.004	400.00	2000.004	400.00{
55-40	TOT ROUND	-1 400.00<	400.00<	400.00<	2000.000	400.00{	2000.00{	400.00<
55-41	TOT ROUND	-1 400.004	900.00<	400.00<	900.00<	400.00{	2000.000	400.00<
SS-41-MS	TOT ROUND	-1 330,004	B30.00{	1630.00	1430.00	1330.00	1700.004	330.00(
SS-41HSD	TOT ROUND	-1 330.00(	830.00<	1620.00	1390.00	1230.00	1760.604	330.00(
55-42	TOT ROUND	-1 400.004	2000.00<	400.00<	2000.000	400.00<	2000.00(	400.00<
SS-43	TOT ROUND	-1 400,004	400.00<	400.00<	2000.00<	400.000	2000.000	400.00(
55-44	TOT ROUND	-1 400.00<	400.00<	400.00(	2000.000	400.00<	2000.004	400.00<
SS-45	TOT ROUND	-1 400.004	400.00<	400.00<	2000.00<	400.0 <b>0</b> (	2000.00<	400.00<
55-46	TOT ROUND	-1 400.004	400.004	400.00<	2000.00(	400.00	2000.00(	400.00{
SS-47	TOT ROUND	-1 400.004	400.00<	400.00<	2000.00<	400.00<	2000.064	400.00<
55-48	TOT ROUND	-1 400.004	400.00K	400.00(	2000.000	400.00{	2000.000	400.00{
55-49	TOT ROUND	-1 400.004	400.00(	400.00<	2000.00<	400.00{	2000.000	400.004
SS-50	TOT ROUND	-1 400.004	400.00{	400.00<	2000.000	400.00{	2000.000	400.004
SS-51	TOT ROUND	-1 B000.004	40000.00<	B000.00(	40000.004	8000.000	40000.000	8000.004
SS-52	TOT ROUND	-1 9000.004	50000.004	9000.000	50000.00<	9000.000	50000.00{	9000.000
55-53	TOT ROUND	-1 10000.004	50000.00(	10000.000	50000.00<	10000.000	50000.000	10000.000
SS-54	TOT ROUND	-1 10000.000	50000.00(	10000.000	50000.00<	10000.00%	50000.00(	10000.000
SS-55	TOT ROUND	-1 400.00{	400.00{	400.000	2000.00<	400.00{	2000.000	400.00{

SDILS QUALITY DATA - ASARCO RI/FS

Sta Id	Anl Event	Ace naphthene ppb	Acenaah thylene pob	Aniline Apb	Anthracne ppb	Benzidine ppb	Benzo(a) anthracne ppu	Benzo(a) pyrene ppb	Benzalb) fluor anthene ppb	Banzo (g,h,i) perylena pab	Benzolk) fluor anthene ppb	Benzyi Alcabol pab	bis(C-chi oroetboxy ) methane ppb
55-27	TOT ROUND-1	2000.004	2000.004	2600.00(	2000.000	20000.000	2000.000	2000.000	2600.000	2000.00(	2006.66N	2000.000	2000.000
SS-28	TOT ROUND-1	400.00(	400.004	400.000	410.00	3000.000	3000.00	3220.00	5550.00	1820.00	400.00N	400.000	400.000
SS-29	TOT ROUND-1	1450.00	400.064	400.000	2500.00	3000.000	5130.00	4410.00	6610.00	2310.00	460.00N	400.064	400.000
SS-30	TOT ROUNG-1	2160.00	400.000	400.004	3050.00	3000.004	5270.00	4510.00	7140.00	1100.00	400.00N	400.000	400.000
\$5-31A	TOT ROUND-1	980.00	800.00	400.00{	1980.00	3000.004	6830.00	6460.00	11000.00	4560.00	400.00N	400.000	400.000
SS-31B	TOT ROUND-1	2690.00	400.000	406.000	4610.00	3000.00(	B260.00	7450.00	13106.06	5380.00	400.0GN	400.000	400.064
SS-32	TOT ROUND-1	400.004	400.00K	400.00	400.00(	3000.000	460.000	400.000	400.000	460.60(	400.06N	400.00(	400.000
55-33	TOT ROUND-1	400.004	400.00(	400.000	400.000	3000.000	£10.00	400.000	1450.00	400.000	400.00N	400.000	400.00K
SS-34	TOT ROUND-1	400.004	400.000	400.000	400.000	3000.000	400.660	<b>46</b> 0.06<	400.060	400.000	400.000	400.600	460.000
SS-35	TOT ROUND-1	400.004	400.004	400.000	400.004	3000.000	400.060	400.004	400.000	400.000	400.000	400.000	400.000
88-38	TOT ROUNG-1	2580.00	400.000	400.004	4080.00	3000.000	11100.00	9546.00	16700.00	5570.00	400.000	400.000	400.000
SS-37	TOT ROUND-1	500.004	500.00(	500.00(	500.064	4000.004	500.000	500.000	500.000	500.004	500.00(	500.004	500.00(
SS-38	TOT ROUND-1	570.00	400.000	400.000	710.00	30 <b>00.00</b> (	1470.00	1430.00	2250.00	750.00	400.00(	400.000	400.000
55-39	TOT ROUND-1	400.000	400.004	400.00(	400.000	3000.000	400.000	400.000	400.000	400.000	400.00(	400.000	400.000
SS-40	TOT ROUND-1	1490.00	590.00	400.064	3900.00	3000.000	9370.00	B980.00	17900.00	4590.00	400,000	400.000	400.000
SS-41	1-DAUGA TOT	1490.00	460.000	400.004	3430.00	900.000	8930.00	8570.00	17500.00	3720.00	400.600	400.000	400.000
89-41-M5	TOT ROUND-1	2090.00	330.06<	330.604	2760.00	330.00<	£980.00	6650.00	13000.00	3660.00	330.004	330.000	330.000
SS-41MSD	TOT ROUND-1	2020.00	330.00<	330.004	2750.00	2700.000	7290.00	5430.00	12400.00	3650.00	330.004	<b>3</b> 30.000	330.000
55-42	TOT ROUND-1	570.00	410.00	400.000	1160.00	10 <b>0</b> 0.000	6250.00	5530.00	10700.00	3430.00	400.00(	400.004	400.604
59-43	TOT ROUND-1	400.000	400.00(	400.000	400.000	3000.000	400.03(	430.00	730.00	510.00	400.000	406.066	400.064
55-44	TOT ROUNG-1	400.000	400.000	400.000	1640.00	3000.000	4106.06	3090.00	5210.00	1450.00	400.000	400.00	400.000
\$\$-45	TOT ROUND-1	1270.00	400.000	400.00(	2830.00	3000.000	7070.00	6320.00	13000.00	3050.00	400.000	400,000	400.000
SS-46	TOT ROUND-1	400.00(	400.00	400.000	400.000	3000.000	1320.00	1359.00	2270.00	850.00	406.000	400.000	400.000
55-47	TOT ROUND-1	400,804	400.000	400.000	400.004	3000.000	720.00	920.00	1720.00	730.00	400.000	460.060	400.660
SS-42	TOT ROUND-1	400.000	400.000	406.007	400.000	3000.000	74).00	700.00	1540.30	500.00	400.000	490.000	460.000
ଜ୍ଞ-ଏବ	TOT ROUND-1	490.000	496.03(	400,000	400.060	1000.00	830.00	720.00	1570.00	540.00	400.004	400.05(	400,000
99- <b>5</b> (	TET ROUNE-E	460.000	460.00(	406.401	400,060	3000.00:	$\{\{0,96\}$	400.66	400.06;	400.000	400.000	496,667	400,000
E9-51	TOT ROUND-1	B300.00	8009.036	<b>E</b> 060.00(	8000.000	70000.000	2000.007	E000.064	1000.004	E000.00:	<b>8</b> 090.000	3000.004	8000.000
SS-52	TOT HOURS-1	9000.6 <b>0</b> 0	9000.000	9000.000	9000.001	70000.000	9600.00	9000.000	9.00,000	7000.000	9006.000	9600.004	9000.000
98-53	TO: ROUND-1	10000.000	10000.000	10000.000	10000.064	20066.00	10000.00.	400(0.66)	10000.000	10000.630	10006.000	10000.001	:6060.000
85-54	10" ROU :0-1	100(0.00(	10000.000	10060.007	10000.000	80000.000	100.0.30.	10000.000	10000.00	10000.000	10000.0000	10000.000	10000.000
SS- 55	TOT ROUND-1	400.00(	400.000	400.000	460.300	3000,000	<b>40</b> 0.007	400.000	400.000	400.000	496.666	400.00	400.000

SOILS QUALITY DATA - ASARCO RI/FS

Sta Id	Anl	Event	bis(2-chl orcethyl) ether ppb	bis(2-ch) oroisopro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Bromosh enyl-phen yl ether ppb	Butyl benzyl phthalate ppb	4-Chloro aniline ppb	2-Chloro maphthlne ppb	4-Chlorop henyl phe nyl ether pab	Chrysene ppb	Dibenzo (a,h) anthracne ppb	Dibenzo furan ppb	1,2- Dicloro banzene ppb
SS-27	TOT	ROUND-1	2000.004	2000.000	2000.00(	2090.004	2000.00{	2000.004	2000.000	2000.000	2500.00	2000.00{	2000.000	2000.004
55-28		ROUND-1	400.000	400.00<	400.004	400.004	400.000	400.000	400.000	400.000	3190.00	400.004	400.004	400.004
55-29		ROUND-1	400.004	400.00<	400.00(	400.000	400.004	400.000	400.000	400.00(	5130.00	400.000	1000.00	400.00<
55~30	TOT	ROUND-1	400.000	400.004	400.000	400.004	400.004	400.00<	400.000	400.004	4890.00	400.004	1700.00	400.000
SS-31A	TOT	ROUND-1	400.004	400.00<	400.004	400.004	400.004	400.00(	400.664	400.000	8740.00	1100.00	830.00	400.004
SS-31B	TOT	ROUND-1	400.004	400.000	400.000	400.00(	400.00<	400.004	400.000	400.00<	9220.00	1160.00	2300.00	400.000
<b>55-32</b>	161	ROUND-1	400.004	400.004	400.004	400.004	400.000	400.00(	400.000	400.00(	400.00(	400.004	400.000	400.004
SS-33	101	ROUND-1	400.00(	400.00(	400.004	400.004	400.000	400.00(	400.000	400.000	990.00	400.004	400.000	400.000
SS-34	TOT	ROUND-1	400.00<	400.00	400.004	400.004	400.00<	400.004	400.000	400.000	400.000	409.000	400.600	400.004
SS-35	TOT	ROUND-1	400.00<	400.00<	400.004	400.000	400.000	400.000	400.000	400.000	400.004	400.000	400.000	400.000
85-38	TO?	ROUND-1	400.000	400.004	450.00	400.00<	400.004	460.004	400.004	400.00(	11900.00	1520.00	1900.00	400.000
SS-37	TOT	ROUND-1	500.00{	500.000	500.004	500.00K	500.000	500.00<	500.004	500.004	500.000	500.00(	500.000	500.000
SS-38	TOT	ROUND-1	400.004	400.00{	530.00	400.004	400.004	400.000	400.000	400.06<	1500.00	400.000	400.00(	400.004
55-39	TOT	ROUND-1	400.004	400.00(	400.000	400.00(	400.00(	400.004	400.00	400.000	400.004	400.000	400.00(	400.000
SS-40	TOT	ROUND-1	400.000	400.000	400.00(	400.064	400.000	460.004	400.000	400.000	10900.00	1640.00	1800.00	400.004
55-41	TOT	ROUND-1	400.000	400.000	400.00<	400.004	400.00<	400.00(	400.000	400.000	11500.00	400.000	1100.00	400.000
ES-41-HS	101	ROUND-1	330.00<	330.004	330.000	330.00(	330.004	330.004	330.000	330.004	7980.00	330.004	<b>9</b> 30.00	330.004
SS-41MSD	TOT	ROUND-1	330.00<	330.00(	330.004	330.00<	330.00(	330.000	330.00(	330.00<	B290.00	330.000	B36.00	330.00(
55-42	TOT	ROUND-1	400.00<	400.004	400.004	400.004	400.00<	400.004	400.000	409.004	B470.00	400.004	400.00<	400.004
55-43	TOT	ROUND-1	400.000	400.00<	400.00	400.00<	400.000	400.000	400.000	400.000	400.004	400.000	400.000	400.00(
SS-44	101	ROUND-1	400.00<	400.004	400.004	460.904	400.00<	400.00(	400.00<	400.000	3730.00	400.00(	400.000	400,000
SS-45	TOT	ROUND-1	400.004	400.00(	400.00<	460.00(	400.064	400.000	400.00	400.00(	7810.06	550.00	1200.00	400.604
55-45	TGT	ROUND-1	400.00(	400.000	400.000	400.000	400.000	400.904	400.000	400.000	1540.00	400.000	400.00(	400.000
SE-47	TOT	ROUND-1	400.000	400.00<	<b>400.</b> 69(	400.000	400.004	400.000	400.000	400.000	1050.00	400.000	400.304	409.000
55-48	TGT	ROUND-1	490.00{	400.004	490.000	400.00<	400.004	400.004	460.604	400.00<	940.00	400.000	400.000	400,09(
SS-49	TOT	ROUND-1	400.00<	400.00<	400.000	400.00{	400.000	400.000	450.000	400.000	1030.60	400.00(	460.00(	400.000
SS-50	101	ROUND-1	400.000	490.004	409.664	400.004	400.000	400.00(	400.00	400.066	400.060	400.004	400.000	400.00(
58-51	101	ROUND-1	8000.000	B000.00K	\$600.00K	B006.06(	B000.000	B000.000	B000.00K	8000.000	8000.000	B000.000	8000.000	8000.004
\$\$-52	101	ROUND-1	9000.000	500 <b>0.</b> 00(	9000.000	<b>9</b> 00 <b>0.</b> 004	9000.000	9600.000	9000.000	9000.000	9000.004	9000.664	9000.000	9000.000
59-53		ROUND-1	10000.060	10000.000	10000.000	10000.000	10000.00(	10000.000	10000.000	10000.000	10000.000	10060.064	10000.004	10000.000
SS-54	TÜT	REUND-1	10000.000	10069.000	16000.000	16000.690	10000.000	10000.000	10000.004	10000.000	10000.000	10000.004	10000.000	10000.000
SS-55	TOT	ROUND-1	400.000	400.000	400,000	400.00(	400.064	400.000	460.000	400.000	400.000	400.000	400.004	100.0 <b>0</b> (

Parametrix Inc. -- Environmental Data System SURFICIAL SDILS - ASARCO (BASE NEUTRALS)

		1,3- Dichloro	1,4- Dichloro	3,3'- Dichloro	Diethyl	Dimethyl	Di-n- Rutyl	2,4- Dinitro	2,6- Dinitro	Di-n- Octyl	Fluor		Hexa chloro
A_1	F				•	•	•						benzene
	FAGUE	ppo	ppo	рри	ppo	ppo	ppo	 ppo	ppo	ppo		հեր	ρρ <b>5</b>
TOT	ROUND-1	2000.00(	2000.000	4000.00(	2000.00<	2000.00(	2000.000	2000.000	2000.00<	2000.00(	4200.00	2000.000	2000.00(
TOT	ROUND-1	400.00<	400.000	700.00(	400.00<	400.00<	400.004	400.000	400.004	400.0 <b>0</b> <	4820.00	400.00<	400.00<
TOT	ROUND-1	400.00<	400.00<	700.000	400.000	400.00<	400.000	400.00(	400.00<	400.00<	12900.00	2130.00	400.00<
TOT	ROUND-1	400.00{	400.00	800.004	400.00<	400.00<	<b>40</b> 0.00<	400.00	400.00<	400.00<	12000.00	3010.00	400.004
TOT	ROUND-1	400.004	400.00{	800.00<	400.00<	400.00<	400.000	400.000	400.00<	400.000	16700.00	1940.00	400.00<
TOT	ROUND-1	400.00(	400.00<	B00.00<	400.00{	400.00<	400.00(	400.000	610.00	400.000	23000.00	35B0.00	400.00<
TOT	ROUND-1	400.00{	400.004	800.004	400.000	400.00(	400.00(	400.004	400.00(	400.000	400.004	400.00<	400.000
			400.00<	800.00<	400.00(	400.004	400.00(	400.00{	400.00<	400.00<	1910.00	400.000	400.004
			400.00<	800.004	400.00<	400.00(	400.004	400.00<	400.00(	400.000	400.004	400.00<	400.00<
					400.004	400.00<					400.00(	400.000	400.00{
					400.004								400.00<
													500.004
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													400.064
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													400.00(
													B000.00(
													9000.000
													10000.000
													10000.000
													400.000
	707 707 707 707 707 707 707 707 707 707	An1 Event  TOT ROUND-1	Dichloro   benzene	Dichloro   Dichloro   Denzene   De	Dichloro   Dichloro   Dichloro   Denzidine   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppb   Ppp   Ppb   P	Dichloro   Dichloro   Dichloro   Dichloro   Diethyl   phthalate   ppb	Name	No.   Dichloro   Dic	Dichloro   Dichloro	Rounds			Pickloro   Dichloro   Dichloro   Dichloro   Dichloro   Diebhy    Diebhy

SURFICIAL SOILS - ASARCO (BASE NEUTRALS)

		N-Nitroso	N-Nitroso			i,2,4-Tri	
		dipropyl	diphenyl	Phen		chloro	
		amine	agine(1)	anthrene	Fyrene	benzene	FCBs
Sta Id	Anl Event	ррь		ppp	ppb	ppb	ppb
SS-28	TOT ROUND-1	400.00(	400.00(	2830.00	4070.00	400.000	1000.00(
SS-29	TOT ROUND-1	400,000	400.000	13200.00	15100.00	400.000	1000.000
SS-30	TOT ROUND-1	400.004	400.00(	14200.00	12800.00	400.00<	1000.000
55-31A	TOT ROUND-1	400.000	400.00<	12100.00	19060.00	400.00(	1000.000
SS-31B	TOT ROUND-1	400.000	400.004	23500.00	24500.00	400.060	1000.004
SS-32	TOT ROUND-1	400.000	400.000	400.000	400.004	400.004	4100.00
22-33	TOT ROUND-1	400.00<	400.00(	1070.00	1640.00	400.00<	4720.00
55-34	TOT ROUND-1	400.00<	400.000	400.00<	400.00	400.00<	1000.00<
SS-35	TOT ROUND-1	400.00(	400.00(	400.000	400.000	400.00<	1000.00N
55-36	TOT ROUND-1	400.004	400.060	17800.00	29600.00	400.000	1000.00N
55-37	TOT ROUND-1	500.00<	500.004	500.00<	500.00(	500.00<	1000.00N
SS-38	TOT ROUND-1	400.00<	400.00<	3300.00	2930.00	400.000	3960.003
55-39	TOT ROUND-1	400.00<	400.004	400.004	400.00R	400.00(	1000.00N
55-40	TOT ROUND-1	400.004	400.004	22600.00	20300.00J	400.000	1000.00N
SS-41	TOT ROUND-1	400.004	400.004	21600.00	26000.00R	400.00{	1000.00N
SS-41-M	S TOT ROUND-1	1060.00	330.00(	17600.00	17300.00R	1100.00	10300.00
SS-41MS	D TOT ROUNG-1	930.00	1390.00	15600.00	22900.00R	1030.00	10900.00
55-42	TOT ROUND-1	400.00<	400.00<	B850.00	13200.00J	400,004	1000.00N
55-43	TOT ROUND-1	400.004	400.064	400.00{	430.00J	400.004	1080.00J
55-44	TOT ROUND-1	400.004	400.004	8190.00	12200.00J	400.000	1000.00N
55-45	TOT ROUND-1	400.00<	400.00<	18600.00	15900.00J	400.00(	1000.00M
55-46	TOT ROUND-1	400.00<	400.004	1670.00	3150.00J	400.004	1180.00J
SS-47	TOT ROUND-1	400.00<	400.00<	1040.00	1650.00J	400.000	1000.00N
55-48	TOT ROUND-1	400.004	400.00(	690.00	1430.00J	400.004	1000.0CN
55-49	tot round-1	400.00<	400.004	1100.00	1900.003	400.004	1000.0001
SS-50	TOT ROUND-1	400.00(	400.000	400.004	400.00R	400.00<	1000.00N
SS-51	TOT ROUND-1	8000.004	B000.00(	B000.00K	B000.00K	8000.060	1000.00N
SS-52	1-DAUGA TOT	9000.000	9000.000	9000.000	9000.004	9000.000	1000,000
SS-53	TOT ROUND-1	10000.000	10000.000	10000.004	10000.000	10000.000	1000.00N
SS-54	TOT ROUND-1	10000.000	10000.000	10050.00(	10000.004	10000.004	2000.00N
SS-55	TOT ROUND-1	400.00<	400.00(	400.000	400.000	400.00%	1000.00M
55-58	TOT ROUND-1	400.004	<b>400.0</b> 00	400.000	400.004	400.064	1600.00%
SS-57	TOT ROUND-1	400.000	400.004	1370.00	2490.00	400.000	1000.00M

SURFICIAL SOILS - ASARCO (BASE NEUTRALS)

Sta Id	Anl	Event	N-Nitroso dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Phen anthrene ppb	Pyrene ppb	1,2,4-Tri chloro benzene ppb	PC8s ppb
SS-27	TOT	ROUND-1	2000.00<	2000.004	3400.00	4400.005	2000.00,	1000.00M
SS-28	TOT	ROUND-1	400.00{	400.004	2630.00	4070.00	400.00	1000.000
55-29	TOT	ROUND-1	400.00{	400.00{	13200.00	15100.00	400.00<	1000.00<
SS-30	TOT	ROUND-1	400.00<	400.000	14200.00	12800.00	400.00(	1000.000
S5-31A	TOT	ROUND-1	400.00	400.00<	12100.00	19000.00	400.00<	1000.00<
SS-31B	TOT	ROUND-1	400.004	400.004	23500.00	24500.00	400.00(	1000.00<
SS-32	TOT	ROUND-1	400.00<	400.00{	400.000	400.00	400.00<	4100.00
55-33	TOT	ROUND-1	400.00{	400.00	1070.0 <b>0</b>	1640.00	400.00<	4720.00
SS-34	TOT	ROUND-1	400.004	400.00{	400.0 <b>0</b> <	400.00<	400.000	1000.000
SS-35	TOT	ROUND-1	400.004	400.004	400.00<	400.000	400.00<	1000.00N
SS-34	TOT	ROUND-1	400.004	400.00<	17800.00	29400.00	400.00<	1000.00N
55-37	TOT	ROUND-1	500.00<	500.004	500.00<	500.00<	500.00<	1000.00N
SS-3B	TOT	ROUND-1	400.000	400.004	3300.00	2930.00	400.004	3960.003
55-39	TOT	ROUND-1	400.00	400.00(	400.00<	400.00<	400.00<	1000.00N
SS-40	TOT	ROUND-1	400.004	400.000	22600.00	20300.00	400.00{	1000.00N
55-41	TOT	ROUND-1	400.00<	400.004	21600.00	26000.00N	400,004	1000.00N
SS-41-MS	TOT	ROUND-1	1060.00	330.004	17600.00	17300.00N	1100.00	10300.00
SS-41HSD	TOT	ROUND-1	930.00	1390.00	15400.00	22900.00N	1030.00	10900.00
SS-42	TOT	ROUND-1	400.00<	400.000	8850.00	13200.00	400.004	10 <b>0</b> 0.00N
55-43	TOT	ROUND-1	400.000	400.00(	400.00<	430.00	400.00<	10B0.00J
55-44	TOT	ROUND-1	400.000	400.004	8190.00	12200.00	400.00<	1000.00N
SS-45	TOT	ROUND-1	400.000	400.00<	18400.00	15900.00	400.00<	1000.00%
55-46	TOT	ROUND-1	400.004	400.00<	1670.00	3160.00	400.00<	1180.003
SS-47	101	ROUND-1	400.004	400.094	1050.00	1650.00	400.004	1000.00N
55-4B	TOT	ROUND-1	400.004	400.00(	890.00	1480.00	400.000	1000.00N
55-49	101	round-1	400,000	400.00<	1100.00	1900.00	400.000	1000.00N
SS-50	101	rdund-1	400.000	400.004	400,600	400.00	406.000	1000.00N
SS-51		ROUND-1	8000.0 <b>0</b> <	B000.00(	B000.00(	B000.00K	B000.00(	1000.00M
<b>SS</b> -52		ROUND-1	9000.000	9000.000	9000.000	9000.000	9000.000	1000.00M
SS-53		RGUND-1	10000.000	10000.000	10000.000	10000.00(	10000.000	1000.00N
SS-54		RDUND-1	10000.000	10000.000	10000.000	10000.000	10000.00(	2000.00N
SS-55	101	ROUND-1	400.000	400.00<	400.00<	400.000	400.00{	1000.00%

BOILS QUALITY DATA - ASARCO RI/FS

Sta Id	Anl	Event	Benzoic Acid ppb	2-Chloro phenol ppb	2.4-Di chloro phenol ppb	2.4-Bi methyl phenol ppb	2,4-Di nitro phenol ppb	2-Methvi phenol ppb	4-Methyl phenol ppb
SS-56	TOT	ROUND-1	2000.004	400.00<	400.00<	400.00<	2000.00<	400.00<	460.00(
SS-57		ROUND-1	2000.00(	400.00{	400.004	400.004	2000.00(	400.00(	400.000
SS-58A		ROUND-1	20000.004	4000.004	4000.000	4000.004	20000.004	4000.004	4000.000
SS-58B		ROUND-1	20000.004	4000.000	4000.004	4000.004	20000.004	4000.004	4000.000
SS-59		ROUND-1	10000.00{	2000.004	2000.000	2000.00<	10000.004	2000.000	2000.000
55-60		ROUND-1	40000.00{	9000.004	9000.004	9000.004	40000.000	9000.004	9000.000
· 55-60-MS			34000.004	6600.004	6600.000	6600.000	34000.000	6400.004	6600.000
SS-60MSD			34000.004	6600.000	6600.000	6600.000	34000,000	6600.000	300.004
SS-61		ROUND-1	2000.004	400.00<	400.004	400.004	2000.004	400.004	400.004
SS-62		ROUND-1	2000.004	400.00{	400.004	400.000	2000.004	400.00<	400.004
55-63A		ROUND-1	2000.00{	400.00<	400.00<	400.00<	2000.004	400.004	400.000
SS-63B		ROUND-1	2000.004	400.004	400.00(	400.004	2000.004	400.004	400.004
55-64		ROUND-1	20000.004	4000.00<	4000.004	4000.000	20000.004	4000.00<	4000.000
55-65		ROUND-1	2000.004	400.004	400.00<	400.00{	2000.004	400.004	400.000
55-66	TOT	ROUND-1	2000.004	400.00<	400.000	400.004	2000.004	400.00<	400.00(
55-67		ROUND-1	2000.004	400.004	400.00<	400.004	2000.004	400.00<	400.000
· SS-68	TOT	ROUND-1	2000.00{	400.004	400.00<	400.00<	2000.000	400.00{	400.00(
- SS-68-MS			1700.004	2570.00	330.00<	330.004	1700.004	330.00<	330.00<
·SS-68MSD			1700.004	2500.00	330.00<	330.00<	1700.004	330.00<	330.00(
SS-69	TOT	ROUND-1	2000.00<	400.00<	400.000	400.00<	2000.00<	400.000	400.000
SS-70	TOT	ROUND-1	90000.00R	20000.00R	20000.00R	20000.00R	90000.00R	20000.00R	20000.00R
~ 55-MW10	TOT	ROUND-1	2000.000	400.004	400.004	400.004	900.004	400.004	400.000
SS-HW11	TOT	ROUND-1	2000.00N	400.00N	460.00N	400.00N	2000.00N	400.00N	400.00N
SS-M412	TOT	ROUND-1	2000.000	400.00%	400.00<	400.000	2000.000	400.00{	400.00<
SS-MW12U	TOT	ROUND-1	2000.000	400.00(	400.000	400.000	2000.004	400,000	400.004
~ SS-MW4	TOT	ROUND-1	2000.004	400.004	400.000	400.00<	2000.000	400.00{	400.000
- SS-MW5		ROUND-1	2000.00R	400.00R	400.007	400.00R	2000.00R	400.00R	400.00R
SS-MW7		ROUND-1	10000.004	2000.00(	2000.00(	2000.000	10000.004	2000.004	2000.004
. SS-M#8	TOT	ROUND-1	2000.004	400.004	400.000	400.004	2000.00(	400.004	400.000

SOILS DUALITY DATA - ASARCO RI/FE

Sta Id	Anl	Event	2-Nitro phenal ppb	4-Nitro phenol ppb	4-Chloro- 3-methyl phenol ppb	Penta chloro phenol ppb	Phenol ppb	2.4,5-Tri chloro phenol ppb	2,4,6-Tri chloro phenol ppb
SS-56	TOT	ROUND-1	400.000	400.00<	400.00{	2000.004	400.000	2000.00	400.00
SS-57	TOT	ROUND-1	400.00<	400.00{	400.00<	2000.00{	400.00<	2000.004	400.00{
SS-58A	TOT	ROUND-1	4000.000	20000.00(	4000.00<	20000.00(	4000.00<	20000.00{	4000.00{
SS-58B	TOT	ROUND-1	4000.00{	20000.000	4000.000	20000.004	4000.000	20000.004	4000.000
SS-59	TOT	ROUND-1	2000.00<	10000.000	2000.00<	10000.00<	2000.00<	10000.000	2000.000
SS-60	TOT	ROUND-1	9000.004	40000.000	9000.000	40000.000	9000.004	40000.000	9000.000
SS-60-KS	TOT	ROUND-1	6400.004	34000.004	6600.000	34000.00<	6600.000	34000.00(	6600.004
SS-60MSD	TOT	ROUND-1	6600.004	34000.004	6600.00<	34000.00(	6500.00<	34000.004	££00.00{
SS-61	TOT	ROUND-1	400.00<	400.00<	400.00<	2000.00(	400.00(	2000.000	400.00{
SS-62	TOT	ROUND-1	400.004	400.00<	400.00<	2000.000	400.00(	2000.000	400.004
SS-63A	TOT	ROUNC-1	400.00<	400.00{	400.00<	2000.00(	400.00<	2000.00<	400.00<
55-63B	TOT	ROUND-1	400.00<	400.000	400.00(	2000.00<	400.004	2000.004	400.004
SS-64	TOT	ROUND-1	4000.000	20000.004	4000.000	20000.00(	4000.000	20000.004	4000.000
55-65	TOT	ROUND-1	400.004	400.00<	400.004	2000.000	400.000	2000.000	400.00(
55-66	TOT	ROUND-1	400.004	400.004	400.000	2000.000	400.004	2000.000	400.000
SS-67	TOT	ROUND-1	406.00<	400.00<	400.00<	2000.000	400.004	2000.00<	400.000
SS-&8	TOT	ROUND-1	400.004	400.000	400.00<	2000.004	400.00(	2000.00(	400.000
SS-&B-MS	TOT	ROUND-1	330.00<	1900.00	4530.00	2200.00	2490.00	1700.000	330.000
SS-68MSD	TOT	ROUND-1	330.004	2030.00	2690.00	1830.00	2460.00	1700.004	330.00(
SS~69	TOT	ROUND-1	400.004	400.000	400.004	2000.000	400.000	2000.000	400.000
55-70	TOT	ROUND-1	20000.00R	90000.00R	20000.00R	90000.00R	20000.00R	90000.00R	20000.00R
SS-MW10.		ROUNG-1	400.00(	900.000	400.000	900.004	400.000	2000.000	400.000
SS-HW11	TOT	ROUND-1	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
58-MN12	TOT	ROUND-1	400.004	2000.000	400.004	2000.00<	400.004	2000.004	400.000
SS-MW12U	TOT	ROUND-1	400.00{	2060.00(	400.000	2000.000	400.000	2000.000	400.00(
SS-MW4	TOT	ROUNG-1	400.004	2000.00<	400.000	2000.600	400.00<	2000.00<	400.000
55-KW5	TOT	ROUND-1	400.00R	2000.00R	400.008	2000.00R	400,00R	2000.00R	400.00R
SS-MH7	TOT	ROUND - 1	2000.00(	10000.00<	2000.000	10000.000	2000.004	10000.000	2000.000
SS-MMB	TOT	ROUND-1	400.004	2000.09(	400.000	2000.000	400.004	2000.064	400.000

SOILS DUALITY DATA - ASARCO RI/FS

			Ace	Acenaph	<b>A.131</b>	0-11	B	Benzula)	Benzo(a)	Benzo(b) fluor	Penzo (g,h,i)	Benzo(k) fluor	Benzy!	pis(2-chl proethoxy
Sta Id	Anl	Event	naphthene ppb	thylene ppt	Aniline ppb	Anthracne ppb	Benzidine ppb	anthracne pab	pyrene ppb	anthene ppb	perylene ppb	anthene ppb	Alcahol ppb	lmethane ppb
SS-56	TOT	ROUND-1	400.000	400.00(	400.00(	400.004	4000.00<	400.000	400.00<	400.000	400.00	400.004	460.00(	400.00(
SS-57		ROUND-1	400.004	400.004	400.004	440.00	4000.000	760.00	760.001	400.00N	400.00N	400.00N	400.004	400.00
SS-58A		RCUND-1	4000.000	4000.004	4000.000	4000.000	40000.000	4000.000	4000.000	4000.004	4000.000	4000.000	4000.00(	4000.000
SS-588		ROUND-1	4000.000	4000.000	4000.000	4000.004	40000.000	4000.004	4000.004	4000.000	4000.004	4000.004	4000.000	4000.000
88-59		ROUND-1	2000.004	2000.00(	2000.00(	2006.000	20000.000	21000.000	2000.004	2000.004	2000.004	2000.064	2000.004	2000.00(
SS-50		ROUND-1	9000.004	9000.000	9000.004	9000.000	70000.004	9000.000	9000.004	7000.004	9000.004	9000.000	9000.000	9000.000
55-60-MS			6600.000	6400.000	6400.000	6600.000	52000.000	6600.000	6600.00<	6600.000	6600.000	6600.000	6600.000	6600.000
68-60MS	TOT	ROUND-1	6600.000	6600.004	6600.000	6600.000	54000.000	6600.000	6600.000	6600.000	6500.000	6£00.00K	6600.000	6500.000
SS-61	TOT	ROUND-1	400.000	400.00(	400.00<	400.000	3000.004	400.00N	400.00N	400.00N	400.00N	400.00M	400.060	400.000
55-62	TOT	ROUND-1	400.000	400.004	400.00<	400.000	3000.004	400.00N	400.00N	400.00N	400.00N	400.00N	400.004	400.000
55-63A	TOT	ROUND-1	400.00{	400.004	400.000	400.004	3000.00<	400.004	400.GGN	470.003	400.00N	400.00N	400.000	400.004
SS-63B	TOT	ROUND-1	400.00<	400.000	400.000	400.004	3000.000	400.00<	400.00<	480.00	400.064	400.000	400.064	400,000
SS-64	TOT	ROUND-1	4000.004	4000.000	4000.000	4000.000	30000.00<	4000.000	4000.004	4000.004	4000.004	4000.000	4000.000	4006.004
SS-65	TOT	ROUND-1	400.00<	400.00(	400.00<	400.000	3000.00<	400.060	400.00(	400.004	400.000	400.00(	400.000	400.00<
88-88	TOT	ROUND-1	400.00<	400.00(	400,000	400.00<	3000.00<	400.000	400.000	400.00<	400.00(	400.000	400.00<	400.004
SS-67	TOT	ROUND-1	400.00<	400.000	400.00<	400.00(	3000.064	400.09(	400.00N	400.00N	400.00N	400.00%	400.000	400.004
55-4B	101	ROUND-1	400.00<	400.00<	400.000	400.004	3000.000	1060.00	1170.00	1550.00	7B0.00	400.000	400.004	400,004
55-68-KS	TOT	ROUND-1	1530.00	330.00(	330.00(	430.00	2700.00(	1400.60	1300.00	1770.00	770.00	330.000	330.00(	330.000
SS-46MSD			1600.00	330.00(	330.00(	330.00	2700.004	1860.00	1730.00	2830.00	1130.00	330.004	350.000	330.00<
55-69	TOT	ROUND-1	400.00<	400.004	400.00{	400.00<	3000.60<	400.00N	400.00N	400.00N	400.00N	400.00N	400.00(	400.000
SS-70		ROUND-1	20000.00R	20000.00R	20000.00R	20000.00R	100000.00R	20000.00R	20000.00R	20000.00R	20000.00R	20090.00R	76000.00R	20000.00R
SS-MW10		ROUND-1	400.00<	400.004	400.004	400.000	900.00<	400.000	400.00	400.00(	400.004	400.000	400.000	400.004
S5-MW11		ROUND-1	400.00N	400.00N	400.00N	400.00N	3000.00N	400.0CN	400.00N	400.00N	400.00N	400.00N	400.0CM	400.00N
SS-MW12		ROUND-1	400.004	400.000	400.000	400.000	3000.000	400.000	400.00<	400.000	<b>40</b> 0.064	400.00(	400.000	400.000
SS-HW12U			400.000	400.004	400.00(	400.00<	3060.604	400.001	400.004	409.00(	400.000	400.004	400.00(	409.000
59-MW4		RDUND-1	400.00(	490.000	400,606	490.00(	3000.000	400.004	400,000	400.0 <b>0</b> 0	400.000	400.004	409.000	400.000
SS-MUS		ROUMD-1	400.00R	400.003	400.00R	400.00R	3000.00R	400.00R	400.00R	400.00R	400.00R	400.00R	400.00R	400.00R
SS-MW7		FOUND-1	2000.004	2000.000	2000.000	2000.000	20000.00(	5400.00	3600.00	8400.00	3200.00	2000.004	2000.004	2000.064
ES-MRB	TOT	ROUND-1	400.00K	400.038	400.000	400.000	3000.000	2120.00	2340.00	6 <b>6</b> E0.0 <b>0</b>	2000.00	400.09(	400.000	400.000

EDILS BUALITY DATA - ASARCO RI/FS

			bis(2-ch) oroethyl) ether	bis(2-chl oroisopro pylletter	bis(2-eth ylhexyl) phthalate	4-Bromoph enyl-phen yl ether	Butyl benzyl phthalate	4-Chloro aniling	2-Chioro naphthlne	4-Chlorop henyl phe nyl ether	Chrysene	Dibenzo (a,h) anthracne	Dibenzo feran	1,2- Dicloro benzene
Sta Id	Anl	Event	рро	ppb	ppb	ppb	btp	βab	£bp	ρρö	ppb	bbp	ppt	ppb
SS-56	TOT	ROUND-1	400.00(	400.000	400.000	400.004	400.004	400.004	400.00(	400.000	400.00	400.030	400.000	400.000
SS-57	TOT	ROUND-1	400.000	400.000	400.00{	400.00<	400.00<	400.000	400.000	400.000	1160.00	400.00N	400.060	400.004
S3-58A	131	REUND-1	4000.004	4000.004	4000.004	4000.000	4000.000	4006.060	4000.000	4000.060	4000.000	4000.000	4000.000	4000.000
58-58£	TOT	ROUND-1	4000.00(	4000.000	4000.000	4000.00<	4000.000	4000.064	4000.004	4000.000	4000.600	4000.00(	4000.000	4600.000
SS-59	TOT	ROUND-1	2000.004	2000.000	2000.000	2000.00<	2000.00<	2000.660	2000.00<	2000.000	2006.000	2000.000	2000.004	2000.000
58-80	TOT	round-1	9000.000	9000.000	9000.000	9000.004	9000.000	9000.080	9000.000	9000.000	9000.00(	9000.0 <b>0</b> (	9000.000	9000.000
99-60-M9	TOT	round-1	6600.004	6500.000	6469.600	PF00.00(	6600.000	6600.000	8400.000	6600.00<	£600.00K	6600.00K	6600.000	660.00K
SS-60MSI	TOT	ROUND-1	6600.00K	6600.000	6600.00K	5600.000	6 <b>600.</b> 000	<b>6</b> 600.004	6400.000	6400.000	6600.00K	6600.00(	6500.000	200.004
55-61	101	ROUND-1	400.00<	400.000	400.00N	400.000	400.00N	400.000	406.664	400.060	400.00N	400.00N	400.000	400.000
SS-62	TOT	ROUND-1	400.000	400.000	400.00N	400.000	460.00N	400.000	400.00<	400.000	400.00N	400.00N	460.000	400.000
8 <b>S-</b> 23A	TOT	ROUND-1	400.00(	400.000	<b>40</b> 0.00(	400.00K	400.00<	400.000	400.000	400.000	400.06K	400.00%	400.004	400.000
SS-63B	TOT	£00MD-1	400.00(	400.00<	400.000	400.004	400.000	400.004	400.000	400.00<	400.00(	4 <b>0</b> 0.000	400.000	400.000
SS-64	TOT	ROUND-1	4000,000	4000.000	4000.000	4000.004	4000.000	4000.001	4000.000	4900.000	4000.000	4000.000	4000.000	4000.004
58-85	701	ROUND-1	400.000	400.004	409.000	400.000	<b>40</b> 0.060	400.000	400.000	400.000	400.00K	400.064	400.060	400.000
SS-6Ł	TOT	ROUND-1	400.00<	400.000	400.004	400.00(	400.000	<b>4</b> 50,004	400.000	400.000	400.000	4 <b>0</b> 0.06(	400.00(	400.000
ES-57	101	ROUND-1	400.000	400.004	400.000	400.000	400.000	400.000	460.000	400.000	400.00K	400.00M	406.000	400.000
88-38	101	ROUND-1	400.000	400.000	460,000	400.00<	<b>40</b> 0.064	400.000	400.000	400.000	1176.06	400.000	499.004	400.00
55-68-8S	TŪT	ROUND-1	330.000	330.000	330.000	330.000	330.000	330.000	330.000	330.00K	1430.00	330.064	330.000	330.000
98-48M8D	707	ROUND-1	330.000	330.00K	330.660	330.00<	330.064	330.0X	339.000	330.000	2100.00	330.660	330.000	330.000
SE-49	101	ROUND-1	400.00(	400.000	400.00N	400.000	400.00M	400.000	400.004	400.000	430.003	400.30N	400.004	400.000
SS-70	TOT	RGUND-1	20000.00R	20000.00R	20000.00R	20000.008	20000.00%	20000.60R	20000.00R	20000.0 <b>0</b> %	20000.00R	20000.06E	26606.002	26000.00 <b>R</b>
\$\$-WW10	TOT	REGIND-1	406.000	400.000	460.00(	460.664	400.00 c	400.000	400.000	400.060	460.00(	400.000	409.000	4 <b>6</b> 6.634
SS-KWii	TüT	ROLNO-1	400.00N	400.00N	466.033	400.00N	400.00%	400.00%	460.66N	460.008	466.00N	400.00%	4 <b>0</b> 6.0 <b>6</b> 6	400.00a
SE-MX12	101	RDU&0-1	400.600	400.000	400.064	400.664	400.000	406.26	40à.àà<	400.900	400.000	400.064	400.000	400.000
SS-KW12U	TOT	ROUND-1	460.000	400.000	400.000	400.000	400.000	400.004	<b>40</b> 0.000	400.000	400.000	460.000	400.004	400.000
SS-N24	TOT	ROUND-1	400.000	<b>4</b> 66.064	400.000	400.000	400.004	400.00	430.56%	400.000	400.000	<b>40</b> 0.000	400.000	400.000
รร-หพร	101	ROUND-1	400.0CR	400.00R	400.003	400.00 <b>8</b>	460.00%	400.008	₹00.60 <b>⊼</b>	400.00k	400.00R	490,000	490.008	400.002
SS-MW7	707	RGPND-1	2600.000	2000.000	2676.064	1000.000	2000.004	1000.00	1.066.00	26.9.000	5800.00	2606.061	2000.00:	2000.004
55-MW6	191	ROUND-1	400,000	400,000	400.000	400.000	400.064	400.0tv	400.00	400.000	3570.00	590.00	400,566	400.000

SURFICIAL SOILS - ASARCO (BASE NEUTRALS)

			1,3-	1,4-	3,3'-			Di-n-	2,4-	2,6-	Di-n-			He., a
			Dichloro	Dichloro	Dichlero	Diethyl	Dimethyl	bat y l	Dinitro	Dinitro	Octyl	Fluor		chipro
			benzene	benzene	benzidine	phithalata	phthalate	phthalate	toluene	toluene	Phthalate	anthene	Fluorene	panzane
Sta Id	Fu)	Event		ррф	btp	ppb	ppb		ppb	ppt	ppb	ppb	pşb 	ppb
55-56	TOT	ROUND-1	400.000	400.000	900.000	400.000	400.004	400.000	400.000	400.000	400.000	400.00<	400.061	400.000
SS-57	TO7	ROUND-1	400.004	400.060	900.000	400.000	400.00<	400.004	400.000	400.000	400.00N	1290.00	400.064	400.000
SS-58A	101	ROUND-1	4000.00<	4000.000	9000.004	4000.000	4000.00<	4000.00(	40 <b>00.</b> 00(	4000.000	4000.000	4000.004	4000.000	4000.000
SS-5BB	TOT	ROUND-1	4000.00{	4000.004	9000.000	4000.000	4000.00<	4000.000	4000.000	4000.000	4000.00<	4000.00(	4000.000	4000.004
55-59	TOT	ROUND-1	2000.00<	2000.000	5000.000	2000.000	2000.000	2000.000	2000.000	2000.000	2000.00<	2000.000	2000.00{	2000.00(
SS-£0	TOT	ROUND-1	9000.000	9000.000	20000.000	9000.000	9000.000	9000.004	9000.004	9000.000	9000.004	9000.000	9000.004	9000.000
SS-60-MS	TOT	ROUND-1	6600.004	£600.00K	13000.00(	\$60.00K	6600.000	\$600.000	6600.00<	6600.000	6500.000	6600.000	6600.000	6600.000
55-60M5D	101	ROUND-1	6600.00<	6600.000	13000.000	\$400.000	6600.00<	6600.004	6600.000	<b>6</b> 600.00(	6600.00{	\$60.00K	6600.004	6500.0 <b>0</b> <
55-61	TOT	ROUND-1	400.00(	400.00<	700.00N	400.00K	400.000	400.00(	400.00<	400.004	400.00N	<b>40</b> 0.00<	400.030	400.00(
SS-62	TOT	ROUND-1	400.000	400.000	800.000	400.00<	400.000	400.000	400.064	400.000	400.00N	400.000	400.00K	400.000
SS-E3A	TOT	ROUND-1	400.00<	400.000	800.00<	400.000	400.00<	400.004	400.600	400.00{	400.00N	400.000	400.000	400.00(
5S-£3B	TOT	ROUND-1	400.00{	400.00<	800.000	400.004	400.00<	400.00<	400.00<	400.000	400.004	440.00	400.004	400.0 <b>0</b> (
55-64	TOT	ROUND-1	4000.00<	4000.00<	7000.004	4000.004	4000.004	4000.000	4000.004	4000.004	4000.004	4000.000	4000.004	4000.00(
SS-65	101	ROUND-1	400.000	400.004	700.000	400.00(	400.00<	400.000	400.000	400.004	400.00<	400.00<	400.000	400.000
35-6£	101	ROUND-1	400.000	400.004	<b>80</b> 0.00K	400.004	400.000	400.00(	400.00<	400.00<	400.00<	400.004	400.00(	400.000
SS-67	TOT	RDUND-1	400.004	400.004	800.00(	400.00<	400.004	400.00<	400.004	400.00<	400.GON	400.000	400.004	400.00{
55-6B	701	ROUND-1	400.004	400.000	700.00<	400.000	400.000	400.06<	400.00<	400.004	400.004	1740.00	400.000	400.004
SB-68-MS	TOT	ROUND-1	330.00<	1300.00	<b>570.00</b> €	330.00(	330.004	330.004	1100.00	330.000	330.00{	2070.00	370.00	330.000
SS-LBHSD	101	ROUND-1	330.00<	1330.00	670.000	330.004	330.660	330.000	1130.00	330.004	330 <b>.00</b> <	3030.00	330.000	330.00(
55-69	101	ROUND-1	400.004	400.00<	700.00N	400.000	400.000	400.000	400.000	400.004	400.00N	400.004	400.000	400.000
SS-70	TOT	ROUND-1 ·	20000.00R	20000.00R	40000.008	20000.00R	20000.00R	20000.00R	20000.00R	20000.00R	20000.00R	20000.00R	20000.00R	20000.00R
SS-MH10	TOT	RDUND-1	400.004	400.004	960.064	400.000	490.004	400.064	400.000	400.000	400.00(	400.000	460.00(	400.000
SS-MW11	TOT	ROUND-1	400.06N	400.00N	200.00N	460.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
SS-K#12	TOT	ROUND-1	400.004	400.000	200.00<	400.000	400.000	400.000	400.000	400.000	400.004	400.000	400.004	400.000
39-MW12U	101	ROUND-1	400.004	400.004	800.00(	400.000	400.000	400.00K	400.000	406.004	400.000	400.000	400.004	400.004
SS-NH4	TOT	ROUNG-1	400.004	400.004	800.00(	400.000	460.00<	400.004	400.000	400.000	400.004	400.000	460.00(	400.004
SS-MW5	TOT	ROUNE-1	400.00R	400.00R	700.008	400.005	409.00R	400.966	400.00R	490.00R	400.00R	400.008	400,00R	400.00R
SS-MW7	TOT	ROUND-1	2000.000	2000.000	4000.000	2000.000	2000.000	2000.000	2000.000	2000.000	2000.000	11200.000	2000.00(	2690.000
SS-KW8		ROUND-1	400.00<	400.000	760.664	<b>40</b> 0.00K	400.00(	400.960	400.000	400.000	400.000	1890.00	400.000	400.000

Parametrix Inc. -- Environmental Data System SURFICIAL SDILS - ASARCO (BASE NEUTRALS)

			Hexa	Hexachlor .	Hexa	Indeno								N-Ni troso
			chloro	ocyclapen	chloro	11,2,3-cd	lso	2-Hethyl		2-Nitro	3-Nitro	4-Ni tro	Nitro	dimethyl
			butadiene	tadi ene	ethane	Pyrene	phorone	naphthlne	Naphthlne	aniline	aniline	aniline	benzene	anine
Sta Id	Anl	Event	ppb	ppb	ppb	ppb	ppb	ppb 	ррь	ppb	ppb	ppb	ррь	ppb
55-56	TOT	ROUND-1	400.00<	400.00	400.000	400.00<	400.00<	400.004	400.00	2000.004	2000.004	2000.00(	400.00	400.000
SS-57	TOT	ROUND-1	400.00<	400.00<	400.004	400.00N	400.00<	400.00<	400.000	2000.004	2000.004	2000.00{	400.004	400.000
SS-58A	TOT	ROUND-1	4000.000	4000.00{	4000.00{	4000.00<	4000.00<	4000.000	4000.00(	20000.00<	20000.000	20000.00{	4000.000	4000.00<
SS-588	TOT	ROUND-1	4000.00<	4000.000	4000.00<	4000.00<	4000.00<	4000.00<	4000.00{	20000.00(	20000.000	20000.00{	4000.00<	4000.00<
SS-5 <del>9</del>	TOT	ROUND-1	2000.00(	2000.0 <b>0</b> {	2000.00{	2000.00<	2000.00{	2000.00(	2000.000	10000.00{	10000.00<	10000.000	2000.00<	2000.00<
55-60	TOT	ROUND-1	9000.000	9000.004	9000.00<	9000.004	9000.000	9000.000	9000.000	40000.00<	40000.004	40000.00{	9000.00(	9000.000
55-60-MS	TOT	ROUND-1	6600.004	6600.000	6600.00<	6600.00<	6600.00<	6600.004	FP00.00<	34000.004	34000.00<	34000.00<	6600.000	6600.000
SS-EOMSD	TOT	ROUND-1	6600.00K	6400.004	6600.00<	6600.000	8400.00<	6600.000	6600.000	34000.00<	34000.00<	34000.00<	6600.00<	6600.00<
55-61	TOT	RDUND-1	400.00<	400.00<	400.00{	400.00N	400.00<	400.000	400.004	2000.000	2000.00<	2000.000	400.00(	400.000
55-12	TOT	ROUND-1	400.004	400.004	400.004	400.00N	400.000	400.004	400.004	2000.00(	2000.000	2000.004	400.000	400.00{
85-63A	TOT	ROUND-1	400.004	400.000	400.00(	400.00N	400.00	400.00<	400.00<	2000.000	2000.00{	2000.000	400.000	400.000
55-63B	TOT	ROUND-1	400.00<	400.00(	400.000	400.00(	400.00	40ú.00<	400.00<	2000.000	2000.004	2000.00{	400.00<	400.064
55-64	TOT	ROUND-1	4000.00<	4000.000	4000.000	4000.00<	4000.00<	4000.00<	4000.00{	20000.000	20000.004	20000.00{	4000.000	4000.000
SS-65	TOT	RGUND-1	400.004	400.00<	400.000	400.000	400.00<	400.000	400.000	2000.000	2000.004	2000.000	400.000	400.000
55-66	TOT	ROUND-1	400.000	400.00<	400.000	400.00<	400.00{	400.000	400.00<	2000.004	2000.000	2000.004	400.00<	400.004
SS-&7	101	ROUND-1	400.00<	400.004	400.00<	400.00N	400.00(	400.00	400.00<	2000.004	2000.00<	2000.00	400.00<	400.000
5S-6B	TOT	ROUND-1	409.000	400.00<	400.000	560.00	400.000	400.000	400.00<	2000.000	2000.004	2000.00<	400.000	400.000
SS-68-MS	TOT	ROUND-1	330.000	330.000	330.000	600.00	330.000	330.000	330.000	1700.00(	1700.004	1700.00{	330.00(	330.000
SS-&BMSD	TOT	ROUND-1	330.004	330.00(	330.00<	900.00	330.00<	330.00<	330.004	1700.000	1700.000	1700.000	330.000	330.00<
55-69	TOT	ROUND-1	400.000	400.004	400.000	400.00N	400.000	400.00<	400.000	2000.000	2000.004	2000.004	400.00<	400.000
55-70	TOT	ROUND-1	20000.00R	20000.00R	26000.00R	20000.00R	20000.00R	20000.00R	20000.00R	90000.00R	90000.00R	90000.00R	20000.00R	20000.00R
SS-MH10	TOT	ROUND-1	400.004	400.00{	400.000	400.000	400.000	460.000	400.600	2000.000	2000.004	2000.004	400.004	400.000
SS-MW11	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
SS-##12	TOT	ROUND-1	400.004	400.00(	400.00<	400.00(	400.000	400.000	400.000	2000.00(	2000.004	2000.000	400.00€	400.004
SS-MW12U	TOT	ROUND-1	400.000	400.000	400.000	400.000	400.000	400,000	400.000	2000.000	2000.000	2000.004	400.000	400.004
SS-MH4	TOT	ROUND-1	400.000	400.00(	400.000	400.000	400.000	400.000	400.004	2000.000	2000.000	2000.000	400.003	400.000
SS-NWS	TOT	ROUND-1	400.00R	400.00R	400.00R	400.00R	400.00R	400.00R	400.00R	2000.00R	2000.00R	2000.00R	400.00R	400.00R
SS-MW7	TOT	RGUND-1	2000.000	2000.004	2000.000	3000.00	2000.000	2000.000	2000.000	10000.000	10000.000	10000.004	2000.00(	2000.007
SS-MWB	101	round-1	400.00<	400.00<	400.000	1470.00	400.000	400.000	400.00<	2000.000	2006.000	2000.000	400.000	400,000

SURFICIAL SOILS - ASARCO (BASE NEUTRALS)

	N-Nitroso	N-Nitroso	•		1,2,4-Tri	
	dipropyl	diphenyl	Phaa	•	chloro	
	amine	amine(1)	anthrene	Pyrene	benzene	FOBs
Sta Id Anl Event	ррв	ppb	ppb	apb	ррь	ćąq
SS-58A TOT ROUND-1	400ŭ.00(	4000.004	4000.004	4000.004	4000.004	1000.00N
SS-58B TOT ROUND-1	4000.004	4000.00	4000.004	4000.004	4000.000	1000.00N
SS-59 TOT ROUND-1	2000.00(	2000.000	2000.004	2800.00	2000.000	1000.00N
SS-60 TOT ROUND-1	9000.000	9000.004	9000.00(	9000.004	9000.000	1000.00N
SS-60-MS TOT ROUND-1	6600.00(	6600.004	6600.004	6400.0 <b>0</b> <	6600.004	9300.00
SS-60MSD TOT ROUND-1	6600.00{	\$600.00 <b>&lt;</b>	6600.000	8000.00	6600.000	9400.00
SS-61 TOT ROUND-1	400.00<	400.004	400.000	400.00N	400.000	1006.00W
SS-62 TOT ROUND-1	400.004	400.000	400.000	400.00N	400.000	1000.00N
SS-63A TOT ROUND-1	400.00	400.000	460.004	520.00	400.004	1000.GGN
SS-63B TOT ROUND-1	400.00<	400.00<	400.000	560.00	400.000	1000.00N
SS-64 TOT ROUND-1	4000.000	4000.004	4000.000	4000.004	4000.00<	1000.00%
SS-65 TOT ROUND-1	400.00<	460.00<	400.000	400.000	400.00<	1000.00N
55-66 TOT ROUND-1	400.00<	400.00{	400.000	400.004	400.004	ROO.0001
SS-67 TOT ROUND-1	400.064	400.00<	400.000	400.004	400.00<	1000.00N
1-DAUGA TOT 88-22	400.004	400.00{	2150.00	3350.00	400.004	1000.00N
SS-EB-HS TOT ROUND-1	1400.00	330.00(	3370.60	6330.00	1330.60	9400.00
SS-68MSD TOT ROUND-1	1330.00	330.000	3990.06	6450.00	1330.00	9500.00
SS-69 TOT ROUND-1	400.004	400.000	460.000	640.00J	400.00	1000.00N
SS-70 TOT ROUND-1	20000.00R	20000.00R	20000.00R	20000.008	20000.00R	1000.00R
SS-MW10 TOT ROUND-1	400.00{	400.000	400.00<	400.000	400.00<	1000.00N
SS-HW11 TOT ROUND-1	K00.00N	400.00N	400.00N	400.00N	400.00N	1000.00N
SS-MW12 TOT ROUND-1	400.004	400.004	400.004	400.004	400.000	1000.00N
SS-NW12U TOT ROUND-1	400.00<	400.000	400.000	400.00<	400.000	1000.00N
SS-MW4 TOT ROUND-1	400.000	400.004	400.004	400.064	400.003	1150.063
SS-HW5 TOT ROUND-1	400.00R	400.00R	400.003	470.00R	400.008	1000.60R
SS-MW7 TOT ROUND-1	2000.000	2000,000	2900.00	5400.00	2000.00(	1000.00N
SS-MWB TOT ROUND-1	403.00(	400.000	666.06	2900.60	400.004	1000.00%

## Radiological Parameter Results for Surficial Soil Samples

to the second of

Station Id	Gross Alpha (pCi/g)	Total Uranium ug/g	Radium-226 (pCi/g)
SS-01 SS-02 SS-03 SS-04 SS-08 SS-098 SSS-098 SSS-098 SSS-098 SSS-098 SSS-098 SSS-098 SSS-010 SSS-011 SSS-0	8.5 +/- 2.7 3.3 +/- 2.0 2.7 +/- 1.8 6.6 +/- 3.5 6.6 +/- 1.5 6.6 +/- 1.5 7.0 +/- 1.6 8.3 +/- 1.6 8.3 +/- 1.6 8.3 +/- 1.8 11.0 +/- 0.9 1.0 +/- 0.9 1.0 +/- 0.9 1.2 +/- 1.1 1.2 +/- 1.1 1.2 +/- 1.2 1.1 +/- 0.9 1.2 +/- 1.2 1.1 +/- 0.9 1.2 +/- 1.2 1.1 +/- 0.9 1.2 +/- 1.1 2.1 +/- 0.7 2.1 +/- 0.3 3.2 +/- 1.4 3.2 +/- 1.4 3.2 +/- 1.4 3.3 +/- 1.4 3.3 +/- 1.4 3.4 +/- 1.4 3.5 +/- 1.4 3.6 +/- 1.4 3.7 3.8 +/- 1.7 3.9 +/- 1.4 3.9 +/- 1.4 3.0 -3 3.1 -4 +/- 1.4 3.3 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1	1.56 2.15 1.664 2.15 1.664 0.63 1.80 1.80 1.81 0.82 0.82 0.82 1.92 0.83 0.93 0.93 0.93 0.93 0.93 0.93 0.93 0.9	0.33 +/- 0.05 0.20 +/- 0.03 2.35 +/- 0.27 2.18 +/- 0.42 0.97 +/- 0.09 0.46 +/- 0.31
SS-52	13.0 +/- 4.5	1.91	0.52 +/- 0.24 0.28 +/- 0.15

# Radiological Parameter Results for Surficial Soil Samples

Station Id	Gross Alpha (pCi/g)	Total Uranium ug/g	Radium-226 (pCi/g)
SS-53 SS-54 SS-55 SS-56 SS-57 SS-58 SS-59 SS-60 SS-61 SS-62 SS-63 SS-63 SS-63 SS-64 SS-65 SS-65 SS-66 SS-67 SS-68 SS-68 SS-68 SS-69 SS-69 SS-69 SS-69 SS-61 MW13-S-1 MW12-S-1 MW13-S-1 MW13-S-1	5.5 +/- 4.0 12.6 +/- 4.5 < 0.3 < 0.3 < 0.3 < 0.3 < 0.3 11.7 +/- 4.1 8.1 +/- 4.1 2.4 +/- 1.5 2.5 +/- 1.6 2.0 +/- 1.4 1.9 +/- 1.5 2.8 +/- 1.5 2.8 +/- 1.6 2.5 +/- 0.9 1.9 +/- 0.8 2.3 +/- 0.9 5.0 +/- 1.9 2.7 +/- 1.3 < 0.3 < 0.3 < 0.3 < 0.3 < 0.3 < 0.3 < 0.3 < 0.3 < 0.3	1.71 1.96 0.14 0.49 0.14 0.37 0.30 2.36 1.40 1.13 0.49 0.32 0.40 0.28 0.29 0.41 0.75 0.50 0.43 0.47 0.97 0.85 0.94 0.96 0.92	0.54 +/- 0.33

Source: Lancaster Laboratories, File 4-09-01 in ASARCO Accession System

Road Dust Sampling Data

SAMPLE ID: NEA-001 PARTICLE SIZE: C ANALYSIS ID: MM930

STORAGE TANK

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 1138.+- 10. MICROGRAMS

ELEMENT	r ug/c	UG/CM2		UG/FILTER		PERCENT	
AL	4.2117+-	.5583	27.797+-	3.685	2.443+-	.325	
SI	15.9424+-	2.2389	105.220+-	14.777	9.246+-	1.301	
<b>.</b> F	.3088+-	.0700	2.038+~	.462	.179+-	.041	
S	3.8602+-	.5998	25.477+-	3. <i>9</i> 58	2.239+-	.348	
_CL	-0000+-	.0735	.000+~	.485	.000+-	.043	
ĸ	.8458+-	.0987	5.582+~	. 651	-491+-	.057	
CA	5.7074+-	.6413	37.669+-	4.233	3.310+-	.373	
TI	.4735+-	.0264	3.125+-	.174	. 275+-	.016	
V	.0730+-	.0079	. 482+-	.052	.042+-	.005	
_CR	.1552+-	.0096	1.024+-	<b>.</b> 063	.090+-	.006	
MN	.1762+-	.0106	1.163+-	.070	.102+-	.006	
FE	23.4626+-	1.1826	154.853+~	7.805	13.607+-	. 696	
NI	.1189+-	.0080	.785+-	<b>. 05</b> 3	.069+-	.005	
CN	11.7096+-	<b>.</b> 5933	77.283+-	3.916	6.791+-	.349	
ZN	.7140+-	.0610	4.712+-	.403	.414+-	.036	
GA	.0000+-	.0131	.000+-	.086	.000+-	.008	
AS	5.5977+-	.3537	36.945+-	2.334	3.246+-	.207	
`SE	.0094+-	.0047	.062+-	.031	.005+~	.003	
BR	.O143+-	.0264	.094+-	.174	-008+-	.015	
_RB	.0000+-	.0076	.000+-	.050	-000+-	.004	
SR	.0130+-	.0039	.086+-	.026	.008+-	.002	
Y	.0000+-	.0140	.000+-	.092	.000+~	.008	
ZR	-+0000+-	.0161	.000+-	.106	.000+-	.009	
MO	.0816+-	.0122	.539+-	.081	.047+-	.007	
PD	.0000+-	.0115	.000+-	.076	-000+-	.007	
AG	-0000+-	.0161	.000+-	. 106	.000+~	.009	
CD	.1105+-	.0184	<b>-</b> 729+−	.121	.064+-	.011	
IN	.0311+-	.0199	. 205+-	.131	.018+-	.012	
SN	.0000+-	.0275	-000+-	.182	-000+-	.016	
~SB	.8210+-	.0913	5.419+-	.603	476+-	. 053	
BA	.0000+-	.0913	.000+	.603	.000+-	.053	
LA	.0000+-	.1653	-,000+-	1.091	.000+-	.096	
HG ·	.0364+-	.0182	.240+-	.120	。021+-	.011	
PB	4.0005+-	2055	26.403+-	1.356	2.320+-	. 121	

SAMPLE ID: NEA-002 PARTICLE SIZE: C ANALYSIS ID: MM934

PLATE TREATER

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 536.+- 10. MICROGRAMS

ELEMENT	r UG/C	UG/CM2		. UG/FILTER		PERCENT	
AL	1.3004+-	.1745	8.582+-	1.151	1.601+-	.217	
SI	5.4178+-	.7611	35.758+-	5.024	6.671+-	.945	
P	.1793+-	.0408	1.183+-	.269	.221+-	.050	
S	1.1481+-	. 6806	7.577+-	4.492	1.414+-	.839	
CL	.0000+-	.1150	.000+-	.759	.000+-	.142	
K	.3305+-	.0410	2.182+-	.270	.407+-	.051	
CA	3.1 <i>7</i> 89+-	.3581	20.981+-	2.363	3.914+-	.447	
TI	.1782+-	.0114	1.176+-	.075	.219+~	.015	
V 1	.0232+-	.0037	.153+-	.024	.029+-	.005	
CR	.0668+-	.0049	.441+-	.032	.082+-	.006	
MN	.0710+-	.0051	. 469+-	.034	.087+-	.006	
FE	10.1392+-	.5129	66.919+-	3.385	12.485+-	. 673	
NI	.0635+-	.0050	.419+-	.033	.078+-	.006	
CU	5.8457+-	.2971	38.582+ <del>-</del>	1.961	7.198+-	.390	
ZN	.4052+-	.0328	2.674+-	.216	.499+-	.041	
GA	.0359+-	.0227	.237+-	.150	.044+-	.028	
AS	5.0559+-	. 4587	33.369+-	3.027	6.226+-	. 577	
SE	.0000+-	.0054	.000+-	.036	.000+-	.007	
BR	-+0000+-	.0239	-+000+-	.158	.000+-	.029	
RB	-+0000+-	.0073	.000+-	.048	-+000	.009	
SR	-+0000+-	.0034	.000+~	.022	.000+-	.004	
Υ	.0417+-	-0240	. 275+-	.158	.051+-	.030	
ZR	-+0000+-	.0168	.000+-	.111	.000+~	.021	
MO	.0353+-	.0087	. 233+-	.057	-043+-	.011	
PD	.0000+-	.0101	.000+-	.067	.000+-	.012	
AG	.0000+-	.0118	.000+-	.078	-+000	.015	
CD	.0442+-	.0163	. 292+-	.108	.054+-	.020	
IN	-+0000+-	.0171	-+000+-	.113	.000+-	.021	
SN	-2416+-	.0268	1.595+-	. 177	• <del>297+</del>	.033	
SB	9111+-	.0869	6.013+-	.574	1.122+-	.109	
BA	.0000+-	.0789	.000+-	.521	-+000+-	• 097	
LA	.0000+-	. 1327	.000+~	.876	.000+-	.163	
HG	-+0000+-	.0123	.000+~	.081	.000+-	.015	
PB	7.2187+-	3688	47.643+-	2.434	8.889+-	.483	

SAMPLE ID: NEA-003
PARTICLE SIZE: C
ANALYSIS ID: MM910
REVERRB FURNACE
EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 2490.+- 10. MICROGRAMS

ELEMEN	T UG/C	M2	UG/FIL	_TER	PERCE	NT = _ :
AL	4.7206+-	.6419	31.156+-	4.236	1.251+-	.170
SI	17.6454+-	2.4783	116.459+-	16.357	4.677+-	. 657
F	.9189+-	.2063	6.065+-	1,362	.244+-	.055
S	14.0242+-	2.2041	92.560+-	14.547	3.717+-	.584
CL	-+0000+-	. 2594	.000+-	1.712	.000+-	.069
K	1.6676+-	.1912	11.006+-	1.262	.442+-	.051
CA	6.9579+-	.7815	45.922+-	5.158	1.844+-	.207
TI	.6787+-	.0465	4.479+-	.307	.180+-	.012
V	.0945+-	.0152	.624+-	.100	.025+-	.004
CR	.4310+-	.0235	2.845+-	. 155	.114+-	.006
MN	.3727+-	.0209	2.460+-	.138	.099+-	.006
FE	55.9136+-	2.8138	369.030+-	18.571	14.820+-	.748
NI	.3637+-	.0205	2.400+-	.135	.096+-	.005
CU .	46.7794+-	2.3647		15.607	12.399+-	.629
ZN	3.3670+-	. 2554	22.222+-	1.686	.892+-	.068
GA	-+0000+-	.0448	.000+-	. 296	.000+-	.012
AS	34.6986+-	1,9072	229.011+-	12.588	9.197+-	.507
SE	.0429+-	.0183	.283+-	.121	.011+-	.005
BR	-+0000+-	.1489	.000+-	. 983	.000+-	.039
RB	.0000+-	-0407	.000+-	. 269	.000+-	.011
SR	-+0000+-	.0065	.000+-	.043	.000+-	.002
Υ	-0000+-	.0480	.000+-	.317	.000+-	.013
ZR	-+0000+-	.0280	.000+-	.185	.000+-	.007
MO	.2459+-	.0224	1.623+-	.148	.065+-	.006
PD	-+0000+-	.0428	.000+-	.282	-000+-	.011
AG	. 2345+-	.0375	1.548+-	.248	.062+-	.010
CD	<b>.</b> 2578+-	.0395	1.701+-	.261	.068+-	.010
IN	.1887+-	.0268	1.245+-	.177	.050+-	.007
SN	.7084+-	. 0558	4.675+-	.368	.188+-	.015
SB	4.7250+-	.3143	31.185+-	2.074	1.252+-	.083
BA	.0000+-	.1102	.000+-	.727	.000+-	.029
LA	.0022+-	.1670	.015+-	1.102	.001+-	.044
HG	-0664+-	- 0994	. 438+	- 656	.018+-	.026
PB	14.3252+-	7294	94.546+-	4.814	3.797+-	. 194

SAMPLE ID: NEA-004 PARTICLE SIZE: C ANALYSIS ID: MM914 N.W. REFINERY #1

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 1722.+- 10. MICROGRAMS

ELEMENT UG/CM2		M2	UG/FIL	TER	PERCENT	
AL	4.0526+-	.5378	26.747+-	3.550	1.553+-	.206
SI	12.7778+-	1.7948	84.333+-	11.846	4.897+-	. 689
P	.3744+-	.1012	2.471+-	.668	.144+-	.039
S	10.2430+-	1.2121	67.604+-	8.000	3.926+-	.465
CL	.0000+-	.6015	-+000+-	3.970	.000+-	.231
K	.4564+-	.0926	3.012+-	.611	.175+-	.036
CA	50.7180+-	5.6830	334.739+-	37.507	19.439+-	2.181
ΤI	.3572+-	.0204	2.358+-	.136	.137+-	soo.
V	.0231+-	.0052	.152+-	.034	.009+-	.002
CR	.0746+-	.0054	.492+-	.036	.029+-	.002
MN	.1033+-	.0048	. 682+-	.045	.040+-	.003
FE	10.3324+-	.5226	68.194+-	3.449	3.960+-	.202
NI	.2627+-	.0154	1.734+-	.102	.101+-	.006
CU	6.5010+-	.3302	42.907+-	2.179	2.492+-	.127
ZN	.7225+-	.0466	4.769+-	.308	.277+-	.018
GA	-+0000+-	.0118	.000+~	.078	-000+-	.005
AS	7.0505+-	.4042	46.533+-	2.668	2.702+-	.156
SE	.0133+-	.0048	.088+	.032	-+200.	.002
BR	.0188+-	.0330	.124+-	.218	.007+-	.013
RB	.0000+-	.0093	.000+-	.061	.000+-	.004
SR	.0752+-	.0063	. 496+-	.042	.029+-	.002
Y	.0000+-	.0128	.000+-	.084	-000+-	.005
ZR	.0000+-	.0168	-000+-	.111	.000+-	.006
MO	.0531+-	.0112	.350+-	.074	.020+-	.004
PD	-0000+-	.0131	.000+-	.086	-+000+-	.005
AG	. 1449+-	.0248	. 956+-	. 164	.056+-	.010
CD	.0000+ <del>-</del>	.0219	.000+-	. 145	-000+-	.008
IN	.0000+-	.0204	-000+-	. 135	-+000+-	.008
SN	<b>.</b> 0000+ <del>-</del>	.0282	.000+-	.186	.000+-	.011
SB	2.3580+-	. 1545	15.563+-	1.020	.904+-	.059
BA	-+0000+-	.0896	.000+-	.591	-+000+-	.034
LA	.0064+-	.1672	.042+-	1.104	.002+-	.064
HG	-0000+-	.0156	.000+-	.103	-+000+-	.006
PB	3.5898+-	1847	23.693+-	1.219	1.376+-	.071

#### 199/20-004 PROTOCOL:

SAMPLE ID: NEA-005 PARTICLE SIZE: C ANALYSIS ID: MM942 REFINERY #3 - S. END

EXPOSED AREA: 6.60 SQUARE CM MASS OF DEPOSIT: 588.+- 10. MICROGRAMS

ELEMEN	T UG/C	:M2	UG/FILTER		PERCENT	
AL	4.2027+~	.5564	27.738+-	3.672	4.717+-	.630
SI	11.0147+-	1.5462	72.697+-	10.205	12.363+-	1.748
₽	.2343+-	.0533	1.547+-	.352	.263+-	.060
<b>S</b>	1.4924+-	.2129	9.850+-	1.405	1.675+-	.241
CL	10000+-	.1267	.000+-	. 836	.000+-	.142
K	.5822+-	.0689	3.842+-	. 455	.653+-	.078
CA	4.3908+-	.4938	28.980+-	3.259	4.929+-	.561
TI	.3689+-	.0211	2.435+-	.139	414+-	.025
V	.0245+-	.0053	162+-	.035	.027+-	.006
CR	.0669+-	.0049	.442+-	.032	075+-	.006
MN	.0777+-	.0054	.513+-	.036	.087+-	.006
FE	6.1484+-	.3122	40.579+-	2.061	6.901+-	.370
NI	.1864+-	.0114	1.230+-	.075	.209+~	.013
CU	3.7228+-	.1899	24.570+-	1.253	4.179+~	.225
ZN	-2262+-	.0204	1.493+-	.135	. 254+~	.023
GA	.0087+-	.0043	.057+-	.028	.010+-	.005
AS	2.0544+-	.1205	13.559+-	.795	2.306+-	.141
SĒ	-0169+-	.0030	.112+-	.020	.019+~	.003
BR	.0000+-	.0105	.000+-	.069	.000+~	.012
RB	-+0000+-	.0034	.000+-	.022	.000+~	.004
SR	.0000+-	.0026	-000+-	.017	.000+~	.003
Y	-+0000+-	.0049	.000+-	.032	.000+-	.005
ZR	-+0000+-	.0121	.000+-	.080	.000+~	.014
MO	.0000+-	.0079	.000+-	.052	.000+~	.009
PD	.0046+-	.0082	.030+-	.054	.005+~	.009
AG	.0942+-	.0163	.622+-	.108	.106+-	.018
CD	.0266+-	.0133	.176+-	.088	-+020+-	.015
IN	.0000+-	.0153	.000+-	.101	.000+-	.017
SN	.0000+-	0203	.000+-	134	.000+-	.023
SB	.7277+-	-0808	4.803+-	• 533	.817+-	.092
BA	.1598+ <del>-</del>	- 0799	1.055+-	. 527	. 179+-	.090
LA	.1006+-	.1382	.664+-	.912	.113+-	. 155
HG	-+0000+-	.0063	.000+-	.042	.000+-	.007
PB	1.1106+-	0589	7.330+-	. 389	1.247+-	.069

SAMPLE ID: NEA-006 PARTICLE SIZE: C ANALYSIS ID: MM944 HERSHEKOFF ROASTERS

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 1455.+- 10. MICROGRAMS

ELEME	NT UG/C	M2	UG/FIL	TER	PERCENT	
AL	3.4231+-	. 4556	22.593+-	3.007	1.553+~	.207
SI	10.5560+~	1.4821	69.669+-	9.782	4.788+-	. 673
P	.4381+-	.0995	2.891+-	. 657	.199+-	.045
S	5.7642+-	.8896	38.044+ <del>-</del>	5.871	2.615+-	. 404
CL	.0996+~	.1074	.658+-	.709	.045+-	.049
K	.7775+-	.0928	5.131+-	.613	.353+~	.042
CA	12.2077+~	1.3694	80.571+-	9.038	5.538+~	.622
ΤI	.6146+-	.0336	4.056+-	.222	.279+-	.015
V	.1008+~	.0099	.665+-	.065	.046+~	.005
CR	.2356+-	.0137	1.555+-	.090	.107+-	.006
MN	.3121+-	.0174	2.060+-	.115	-142+~	.008
FE '	52.4856+-	2.6415	346.405+-	17.434	23.808+-	1.209
NI	.1582+-	.0100	1.044+-	.066	.072+-	.005
CU	9.3590+-	. 4746	61.769+-	3.132	4.245+~	.217
ZN	.7776+-	.0561	5.132+-	.370	.353+~	.026
GA	.0276+-	.0180	.182+-	.119	.013+-	.008
AS	9.3484+-	. 5588	61.699+-	3.688	4.241+-	. 255
SE	-+0000+-	.0061	.000+-	.040	-+000+-	.003
BR	.0307+-	.0437	.203+-	.288	.014+-	.020
RB	.0000+	.0122	-+000+-	.081	-+000+-	.006
SR	-+0000+-	-0040	.000+-	.026	-000+-	.002
Y	.0000+-	.0192	.000+-	.127	-000+-	.009
ZR	-+0000+-	.0164	-000+-	.108	-000+-	.007
MO	.0688+-	.0112	. 454+-	.074	.031+-	.005
PD	.0000+-	.0129	.000+-	.085	.000+-	.006
AG	.0000+-	.0163	.000+-	.108	-000+-	.007
CD	.0000+	.0196	.000+-	.129	.000+-	.009
IN	-+0000+-	.0197	.000+-	.130	-000+-	.009
SN	.3111+-	.0297	2.053+-	.196	. 141+-	.014
SB	1.4112+-	.1078	9.314+-	.711	.640+-	.049
BA	.0860+-	.0820	.568+-	.541	.039+-	.037
LA	.1605+-	. 1495	1.059+-	.987	.073+-	.068
HG	.0560+-	.0280	.370+-	.185	.025+-	.013
PB	5.6469+-	2891	37.270+-	1.908	2.561+-	.132

SAMPLE ID: NEA-007 PARTICLE SIZE: C ANALYSIS ID: MM916 S. REFINERY #1

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 590.+- 10. MICROGRAMS

ELEMENT	UG/C	:M2	UG/FIL	TER	PERCENT	
AL	1.3163+-	.1765	8,687+-	1.165	1.472+-	.199
SI	5.4784+-	.7701	36.157+-	5.083	6.126+ <del>-</del>	.868
₽	.1842+-	.0424	1.216+-	.280	.206+-	.048
S	2.5162+-	.3451	16.607+-	2.278	2.815++	.389
CL _	0000+-	.1706	.000+-	1.126	.000+-	. 191 ·
K ,	.3066+-	.0394	2.024+~	.260	·. 343+-	.044
CA	6.0261+-	.6770	39.773+ <del>-</del>	4.468	6.741+-	.766
TI	.2326+-	.0142	1.535+~	. 094	.260+-	.016
V ,	.0247+ <del>-</del>	.0042	.163+-	.028	.028+-	.005
CR	-0593+-	.0046	.391+-	.030	-066+-	.005
MN	.0769+-	.0054	.508+-	.036	.086+-	.006
FE	9.2222+-	.4668	60.867+-	3.081	10.316+-	. 551
NI ,	.1585+-	.0100	1.046+-	.066	. 177+-	.012
CN	5.5066+-	.2800	36.344+~	1.848	6.160+-	.330
ZN	.4001+-	.0316	2.641+-	. 209	. 448+-	.036
GA	.0000+-	.0069	.000+~	.046	.000+-	.008
AS	4.6301+-	.2565	30.559+-	1.693	5.179+-	.300
SE	.0362+~	.0056	.239+-	.037	.040+-	.006
BR	.0000+-	.0221	.000+-	. 146	.000+-	.025
RB	.0000+-	.0063	.000+-	.042	.000+-	.007
SR	.0221+~	.0029	.146+ <del>-</del>	.019	.025+-	.003
Y	.0000+~	.0076	.000+-	.050	.000+-	.009
ZR	-0000+-	.0138	.000+-	.091	.000+-	.015
MO	.0406+-	.0095	.268+-	.063	.045+-	.011
PD	.0149+-	.0097	.098+-	.064	.017+-	.011
AG	.2950+-	.0279	1.947+-	. 184	.330+-	.032
CD	.0831+-	.0162	.548+-	-107	.093 <del>+-</del>	.018
IN	.0000+~	.0200	.000+-	.132	-000+-	.022
SN	.0000+-	.0260	.000+-	. 172	.000+-	.029
SB	1.4112+-	1.1015	9.314+-	. 670	1.57 <del>9+-</del>	.117-
BA	.0728+-	.0852	. 480+-	.562	.081+ <del>-</del>	.095
LA .	.0307+~	.1531	. 203+-	1.010	<u> </u>	. 171
HG	.0000+-	.0091	.000+-	. 060	.000+-	.010
PB	1.9463+-	1013	12.846+-	.669	2.177+-	.119

SAMPLE ID: NEA-008 PARTICLE SIZE: C ANALYSIS ID: MM946 CENTRAL CHANGE HOUSE

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 456.+- 10. MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
AL	2.1064+-	.2802	13.903+-	1.849	3.049+-	.411
SI	6.8635+-	.9639	45.299+-	6.362	9.934+-	1.412
P	.1893+-	.0432	1.249+-	.285	. 274+-	.063
S	1.3958+-	.2173	9.212+-	1.435	2.020+-	.318
CL	.0000+-	.0653	.000+-	.431	.000+-	.095
K	.3467+-	.0425	2.288+-	.281	.502+-	.063
CA	3.0061+-	.3387	19.840+-	2.235	4.351+-	. 479
ΤI	.2397+	0146	1.582+-	.096	.347+-	.022
V	.0337+-	.0047	.222+-	.031	.049+-	.007
CR	.1234+-	.0079	814+-	.052	.179÷-	.012
MN	.0705+-	.0054	.465+-	.036	-102+-	.008
FE	7.7491+-	.3927	51.144+-	2.592	11.216+-	.519
NI	.1082+-	.0074	.714+-	.049	.157+-	.011
CU	6.6748+-	.3390	44.054+-	2.237	9.661+-	.534
ZN	.3080+-	.0326	2.033+-	.215	. 446+-	.048
GA	.0000+-	.0053	.000+-	.೦૩5	-000+-	.008
AS	3.2812+-	.1822	21.656+-	1.203	4.749+-	.284
SE	.0100+-	.0033	-+660.	.022	.014+-	.005
BR	-0000+-	.0157	.000+-	.104	-000+-	.023
RB	-0000+-	.0047	.000+-	.031	-+000+-	.007
SR	.0000+-	.0032	.000+~	.021	-000+-	.005
Y	-+0000+-	.0060	.000+-	.040	-+000+-	.009
ZŔ	.0000+-	.0145	.000+-	.096	.000+-	.021
MO	-+0000+-	.0100	.000+-	.066	-+000+-	.014
PD	.0111+-	.0103	.073+-	.068	.016+-	.015
AG	.0278+-	.0139	.183+-	.092	.040+~	.020
CD	-0316+-	.0158	.209+-	.104	.046+-	.023
IN	.0312+-	.0199	.206+-	.131	.045+-	.029
SN	.0000+	.0249	.000+-	.164	.000+-	.036
SB	.4748+-	.0707	3.134+-	. 467	.687+-	.103
BA	.1022+-	.0937	.675+-	.618	.148+-	.136
LA	-+0000+-	.1612	.000+-	1.064	.000+-	.233
HG	.0000+-	.0106	.000+~	.070	.000+-	.015
PB	1.3780+-	্_ 0725	9.095+	. 478	1.994+-	.114

SAMPLE ID: NEA-009
PARTICLE SIZE: C
ANALYSIS ID: MM948
SURFICIAL DUST SAMPLE
EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 632.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FIL	TER	PERCENT	
AL	4.7316+-	.6263	31.228+-	4.133	4.941+-	. 659
SI	17.5478+-	2.4627	115.816+-	16.254	18.325+-	2.588
F	.1944+-	.0443	1.283+-	.292	.203+-	.046
S	1.0999+-	<u>.</u> 1966	7.259+-	1.298	1.149+-	.206
CL	.0504+-	.0321	.333+~	.212	.053+-	.033
K .	.7910+-	.0920	5.220+-	. 607	.826+-	.097
CA	2.9584+-	.3334	19.526+-	2.200	3.090+-	.352
TI	.4051+-	.0230	2.674+-	.152	.423+-	.025
V	.0373+-	.0061	.246+-	.040	.039+-	.006
CR	.0658+-	.0050	. 434+-	.033	.069+-	.005.
MN	.1047+-	.0048	.691+-	.045	.109+-	. 007
FE -	9.9533+-	.5035	65.692+-	3.323	10.394+-	.551
NI	.0460+-	.0041	.304+-	.027	.048+-	.004
CN	1.4230+-	.0737	9.392+-	. 486	1.486+-	.080
ZN	.3022+-	.0180	1.995+-	.119	.316+-	.019
GA	.0068+-	.0053	.045+-	.035	.007+-	.006
AS	2.9983+-	.170B	19.789+-	1.127	3.131+-	.185
SE	.0206+-	.0036	.136+-	.024	.022+~	.004
BR	.0000+-	.0162	.000+-	.107	.000+-	.017
RB	-+0000+-	-0049	.000+-	.032	.000+-	.005
SR	.0000+-	.0034	.000+-	.022	.000+-	.004
Y	-+0000+-	.0063	.000+-	.042	.000+-	.007
ZR	.0000+-	.0145	.000+-	.096	.000+-	.015
MO	-0000+-	.0098	.000+-	.065	.000+~	.010
PD	.0043+-	.0100	.028+-	.066	.004+~	.010
AG	-+0000+-	.0135	.000+-	.089	.000+-	.014
CD	.0304+-	.0152	.201+-	.100	.032+~	.016
IN	-+0000+-	0185	.000+-	.122	.000+-	.019
SN	-+0000+-	.0253	.000+-	- 167	000+~	.026
SB	2695+-	.0620	1.779+-	. 409	.281+~	.065
BA	. 1021+-	.0944	-674+-	. 623	.107+-	.099
LA	-0000+-	.1634	-000+-	1.078	.000+~	-171
HG	.1119+-	.0335	.739+-	.221	.117+-	.035
PB	1.4471+-	<b>0760</b>	9.551+-	.502	1.511+-	.083

SAMPLE ID: NEA-010 PARTICLE SIZE: C ANALYSIS ID: MM950 UPPER STACK AREA

6.60 SQUARE CM

394.+- 10. MICROGRAMS EXPOSED AREA: MASS OF DEPOSIT:

SI P S C K C T V C M F N C Z G A S B R S Y Z M	.3968+0 .0000+0 .4627+0 .2568+1 .2439+0 .0524+0 .0562+0 .0562+0 .367+4435+0036+0036+0036+00040000+-	381 19.30 740 70.24 197 2.61 832 3.05 428 1.6 0042 3 0042 3 1794 23.1 0042 3 1794 23.1 0036 2.5 0054 0018 26.1 0057 .0022 .0199 .0056 .0033 .0125 .0078 .0094	34+- 9.881 58+- 130 19+- 344 549 54+- 363 95+- 078 52+- 028 346+- 028 371+- 184 242+- 024 927+- 160 447+- 036 686+- 135 686+- 135 686+- 01 524+- 01 686+- 01	.407+007 .039+007 .088+007 .094+008 .5.873+335 .4061+004 .004003 .6.773+385 .007+004 .5039+033 .000+009 .004009 .004009 .006+009 .006+009 .006+009 .006+009 .006+006
Y	.0000+- .0028+- .0000+- .0176+- .0301+- .0008+- .0001+- .0445+- .3445+- .0000+- .0813+- .0460+-	.0033 .0125 .0078 .0094 .0118 .0119	.018+06 .000+05 .116+0 .199+0 .005+0 .001+1 .294+1 2.274+4	83 .003+013 51 .000+015 .029+016

SAMPLE ID: NEA-011 PARTICLE SIZE: C ANALYSIS ID: MM932

N. SIDE UPPER STACK AREA

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 839.+- 10. MICROGRAMS

ELEMENT	. ne/c	M2	UG/FIL	TER	PERCE	ENT .
AL	6.2126+-	.8216	41.003+-	5.422	4.887+-	.649
SI	18.8684+-	2.6480	124.531+-	17.476	14.843+-	2.091
۴	.1957+-	.0453	1.292+-	.299	.154+-	. 036
S	.7203+-	. 1 <i>7</i> 71	4.754+-	1.169	.567+-	.139
CL	-0000+-	.1401	.000+-	.925	.000+-	.110
K	.9138+-	.1064	6.031+-	.702	.719+-	.084
CA	7.5378+-	.8463	49.750+-	5.586	5.930+-	.669
TI	.5019+-	.0279	3.313+-	.184	.395+-	.022
V	-+2950	.0070	.261+-	.046	.031+-	.006
CR	.0439+-	.0039	.290+-	. 026	.035+-	.003
MN	.1099+-	.0070	.725+-	-046	.086+-	.006
FE	7.6505+-	.3878	50.493+-	2.559	6.018+-	.313
NI	.0374+-	.0037	.247+-	.024	.029+-	. 003
CN	1.0680+-	.0558	7.049+-	.368	.840+-	.045
ZN	.5867 <del>+-</del>	.0315	3.872+-	.208	.462+-	.025
GA	.0029+-	.0054	.019+-	.036	.002+-	.004
AS	2.9134+-	.1682	19.228+-	1.110	2.292+-	. 135
SE	.0077+-	.0030	.051+-	.020	.006+-	.002
BR	.0000+-	.0154	.000+-	.102	.000+-	.012
RB	.0000+-	.0047	.000+-	.031	.000+-	.004
SR	.0000+-	.0036	.000+-	.024	.000+-	.003
Y	.0000+-	.0062	.000+-	.041	.000+-	.005
ZR	.0000+-	.0148	.000+-	.098	.000+-	.012
MO	.0000+-	.0094	.000+-	.062	.000+-	.007
PD	.0149+-	.0104	.098+-	.069	.012+-	.008
AG	.0089+-	.0122	.059+-	.081	.007+-	.010
CD	-0218+-	.0159	. 144+-	.105	.017+-	.013
IN	.0253+-	.0194	. 167+-	.128	.020+-	.015
SN	.0535+-	·0240	. 353+-	.158	.042+-	.019
SB	2.0122+-	.1685	13.281+-	1.112	1.583+-	.134
BA	.0000+-	.0879	.000+-	.580	.000+-	.069
LA	.0000+-	.1643	.000+-	1.084	.000+-	.129
HG	.0904+-	.0293	.597+-	.193	.071+-	.023
PB	1.4938+-	્ <sub>•</sub> 0784	9.859+-	.517	1.175+-	.063
		-•				

SAMPLE ID: NEA-012 PARTICLE SIZE: C ANALYSIS ID: MM918 N.W. UPPER STACK AREA

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 1071.+- 10. MICROGRAMS

ELEMENT UG/CM2		UG/FILTER		PERCENT		
AL	5.8158+-	.7700	38.385+-	5.082	3.584+-	. 476
SI	19.7374+-	2.7715	130.267+-	18.292	12.163+-	1.712
P	.3647+-	.0823	2.407+-	.543	.225+-	.051
S	1.0442+-	.7222	6.892+-	4.766	.643+-	.445
CL	.0000+	.1220	.000+-	.805	.000+-	.075
ĸ	1.1144+-	.1285	7.355+-	. 848	.687+-	.079
CA	4.7351+-	.5324	31.252+-	3.514	2.918+-	.329
TI	.5139+-	.0285	3.392+-	. 128	.317+-	.018
V	.0383+-	.0070	.253+-	.046	.024+-	.004
CR	.0578+-	.0046	.381+-	.030	.036+-	.003
MN	.1164+-	.0074	.768+-	.049	.072+-	.005
FE	11.2891+-	.5707	74.508+-	3.767	6.957+-	.358
NI	.0444+-	.0040	.293+-	.025	.027+-	.002
CU	1.8420+-	.0949	12.157+-	. 626	1.135+-	.059
ZN	1.2061+-	.0429	7.960+-	.415	.743+-	.039
GA	.0126+-	.0235	.೦83+~	. 155	.008+-	.014
AS	9,7595+-	.6323	64.413+-	4.173	6.014+-	.394
SE	-+0000+-	.0067	.000+-	.044	.000+-	.004
BR	.0000+-	.0458	.000+-	.302	.000+-	.028
RB	-+0000	.0128	-000+-	.084	.000+-	.008
SR	.0090+-	.0045	.059+-	.030	.006+-	.003
Y	-+0000+-	.0251	-+000+-	.166	-+000+-	.015
ZR	-+0000+-	.0191	-+000+-	. 126	.000+-	.012
MO	.0342+-	.0105	.226+-	.069	.021+-	-006
PD	.0000+-	.0132	.000+-	.087	.000+-	.008
AG	-+0000+-	.0137	.000+-	.090	.000+-	.008
CD	.0940+-	.0213	.620+-	.141	.058+-	.013
IN	.0000+-	.0204	.000+-	.135	.000+-	.013
SN	.1456+-	.0316	.961+-	. 209	.090+-	.019
SB	1.1701+-	<b>.</b> 0977	7.723+-	.645	.721+-	.061
BA	.0000+-	.0978	.000+-	. 645	.000+-	.060
LA	.0000+-	. 1642	.000+-	1.084	.000+-	.101
HG	.1196+-	.0624	.789+-	.412	.074+-	.038
PB	7.5005+-	3831	49.503+-	2.528	4.622+-	.240

SAMPLE ID: NEA-013
PARTICLE SIZE: C
ANALYSIS ID: MM940
UPPER STACK AREA - N.E. SIDE
EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 618.+- 10. MICROGRAMS

ELEMENT	UG/CM2		UG/FIL	UG/FILTER		PERCENT	
AL .	4.7663+-	. 6307	31.458+-	4.163	5.090+-	. 679	
SI	16.8234+-	2.3610	111.034+-	15.583	17.967+-	2.538	
P	.1700+-	.0389	1.122+-	.257	.182+-	.042	
S	1.1571+-	.2079	7.637+-	1.372	1.236+-	.223	
CL.	.0646+-	.0337	. 427+-	.223	.069+-	.036	
K	.7567+-	.0882	4.994+-	.582	.808+-	.095	
CA .	3.6013+-	.4054	23.769+-	2.676	3.846+-	. 437	
TI .	-3694+-	.0212	2.438+-	.140	.395+-	.024	
٧	.0259+-	.0054	.171+-	.036	.028+-	.006	
CR	.0299+-	.0031	<u>.</u> 197+–	.020	.032+-	.003	
MN	.0804+-	.0055	.531+-	.036	.086+-	.006	
FE .	5.5421+-	.2818	36.578+-	1.860	5.919+-	.316.	
NI	.0233+-	.0028	.154+-	.018	.025+-	.003	
CU	. 6790+-	.0361	4.481+-	.238	.725+-	.040	
ZN	.3146+-	.0177	2.076+-	.117	.336+-	.020	
GA	.0053+-	.0056	.035+-	.037	-006+-	.006	
AS	2.5253+-	. 1535	16.667+-	1.013	2.697+-	.170	
SE	.0062+-	.0032	.041+-	.021	.007+-	.003	
BR	-+0000+-	.0134	.000+-	.088	.000+-	.014	
RB .	.0000+-	.0041	.000+-	.027	.000+-	.004	
SR	.0000+-	.0031	-000+-	.020	.000+-	.003	
Y	.0094+-	.0062	.062+-	.041	.010+-	.007	
ZR	.0000+-	.0131	.000+-	086	-000+-	.014	
MO	.0000+-	.0081	.000+-	.053	.000+-	.009	
PD	.0106+-	.0092	.070+-	.061	.011+-	.010	
AG	.0138+-	.0112	.091+-	.074	.015+-	.012	
CD	.0280+-	.0140	.185+-	.092	-+050+-	.015	
IN	.0030+-	.0167	.020+-	.110	.003+-	.018	
SN	.0432+-	.0216	.285+-	.143	.046+-	.023	
SB	.2192+-	.0526	1.447+-	.347	.234+-	.056	
BA -	.1177+-	.0834	.777+-	.550	.126+-	.089	
LA	-0000+-	.1440	.000+-	.950	.000+-	. 154	
HG	.0374 <del>+-</del>	.0187	.247+-	.123	.040+-	.020	
FB	1.5751+-	0825	10.396+-	.544	1.682+-	.092	

SAMPLE ID: NEA-014 PARTICLE SIZE: C ANALYSIS ID: MM920 GODFREY ROASTER

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 1680.+- 10. MICROGRAMS

ELEMENT	UG/C	M2	UG/FIL	_TER	PERCE	ENT
AL	2.2036+-	.3742	14.544+-	2.470	.866+-	. 147
SI	17.1197+-	2.4042	112.990+-	15.868	6.726+-	.945
F	.2736+-	.0623	1.806+-	.411	.107+-	.025
S	3.0156+-	.4641	19.903+-	3.043	1.185+-	.182
CL	.0000+-	.1580	.000+-	1.043	.000+-	.062
K	.8056+-	.0945	5.317+-	.624	.316+-	.037
CA	6.5322+-	.7337	43.112+-	4.842	2.566+-	.289
TI	.5360+-	.0296	3.538+-	.195	.211+-	.012
V	.0535+-	.0077	.353+-	.051	.021+-	.003
CR	.0578+-	.0047	.381+-	.031	.023+-	.002
MN	.1159+-	.0074	.765+-	.049	.046+-	.003
FE	12.0501+-	.6089	79.531+-	4.019	4.734+-	.241
NI	.0972+-	.0069	.642+-	.046	850.	.003
CU	4.9006+-	.2494	32.344+-	1.646	1.925+-	.099
ZN	-9416+-	.0532	6.215+-	.351	.370+-	.021
GA	.0000+-	.0111	.000+	.073	.000+-	.004
AS	66.9136+-	3.3814	441.630+-	22.317	26.297+-	1.338
SE	1.1510+-	.0786	7.597+-	.519	.452+-	.031
BR	.8295+-	.3368	5.475+-	2.223	.326+-	.132
RB	.0000+-	.0915	.000+-	- 604	.000+-	.036
SR	.0146+-	.0073	.096+-	.048	.006+-	.003
Υ.	-+0000+-	.0248	-+000+-	.164	.000+-	.010
ZR	.0000+-	.0178	.000+-	.117	.000+-	.007
MO	.0471+~	.0137	.311+-	.090	.019+-	.005
PD	.0000+-	.0844	.000+-	. 557	.000+-	.033
AG	.0000+-	.0414	-000+-	.273	.000+-	.016
CD	.0000+-	.0237	-+000+-	.156	-+000+-	.009
IN	.0000+-	.0249	.000+-	. 164	.000+-	.010
SN	.1324+-	.0323	.874+-	.213	.052+-	.013
SB	4.8947+-	.3141	32.305+-	2.073	1.923+-	.124
BA	.1662+-	.1051	1.097+-	. 694	.065+-	.041
"LA	.1037+-	. 1871	.684+-	1.235	.041+-	.074
HG	4.9169+-	1.1607	32.452+-	7.661	1.932+-	. 456
PB	3.1454+-	1622	20.760+-	1.071	1.236+-	.064

SAMPLE ID: NEA-015
PARTICLE SIZE: C
ANALYSIS ID: MM922
ARSENIC KITCHEN
EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 4971.+- 10. MICROGRAMS

ELEMEN	NT UG/C	M2	UG/FI	TER	PERCE	ENT -
AL	4.5984+-	.9134	30.350+-	6.029	-611+-	.121
SI	34.1688+-	4.7977	225.514+-	31.665	4.537+-	. 637
P	-48626.	.1440	4.203+-	.950	.085+-	.019
S	.0000+-	2.2375	.000+-	14.768	-+000+-	<u>.</u> 297
	.0000+-	.3663	.000+-	2.418	.000+-	· 049 -
K	2.1652+	.2507	14.290+-	1.655	.287+-	.033
CA	12.6973+-	1.4244	83.802+-	9.401	1.686+-	.189
ΤI	1.1662+-	.0614	7.697+-	. 405	.155+-	. 008
V	.1290+-	.0151	.851+-	.100	.017+-	.002
CR	.1900+-	.0116	1.254+-	077	.025+-	.002
MN	.3305+-	.0183	2.181+-	.121	.044+-	.002
FE	43.7064+-	2.2002	286.462+-	14.521	5.803+-	.292
NI	.3080+-	.0177	2.033+-	<b>.</b> 117.	.041+-	.002
CU	16.9207+-	.8565	111.677+-	5.653	2.247+-	.114
ZN	3.9585+-	.2126	26.126+-	1.403	.526+-	.028
GA	.0000+-	. 0657	.000+-	. 434	.000+-	.009
AS	155.9351+ <del>-</del>	7.9477	1029.172+-		20.704+-	1.056
SE	.4509+-	.0692	2.976+-	<b>.</b> 457	.060+-	.009
BR	-0000+-	.6621	.000+-	4.370	-+000+-	.088
₽B	.0000+-	.1801	.000+-	1.189	.000+-	.024
SR	.0228+-	.0114	.150+-	.075	.003+-	.002
Υ	.0000+-	.0817	.000+-	.539	.000+-	.011
ZR	.0000+-	.0398	.000+-	.263	.000+-	.005
MO	.3468+-	.0306	2.289+-	.202	.046+-	.004
PD	.0000+-	. 4591	.000+-	3.030	.000+-	.061
AG	.2387+-	. 1595	1.575+-	1.053	.032+-	.021
CD	.5782+-	.1120	3.816+-	.739	.077+-	.015
IN	.0000+-	.0402	-000+-	. 265	.000+-	.005
SN	.8441+-	.0798	5.571+-	.527	.112+-	.011
SB	11.6651+-	. 6932	76.990+ <del>-</del>		1.549+-	.092
BA	.0000+-	.1194	-000+-	.788	-000+-	.016
LA	.4210+-	.2160	2.779+-	1.426	.056+-	.029
HG	2.5586+ <del>-</del>	.9173	16.887+-	6.054	.340+-	.122
PB	21.2092+-	1.0787	139.981+-	7.119	2.816+-	.143

SAMPLE ID: NEA-016 PARTICLE SIZE: C ANALYSIS ID: MM952 GODFREY ROASTER - N.

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEFOSIT: 1441.+- 10. MICROGRAMS

ELEMENT UG/CM2		M2	UG/FIL	TER	PERCENT	
AL	6.7617+-	.9006	44.627+-	5.944	3.097+-	.413
SI	24.6552+-	3.4598	162.724+-	22.834	11.292+-	1.587
F	.2767+-	.0631	1.825+-	.417	.127+-	.029
S	2.6425+-	.4046	17.440+-	2.670	1.210+-	.186
CL	.0000+	.1443	.000+-	.953	.000+-	.066
K	1.3296+-	.1528	8.775+-	1.009	.609+-	.070
CA	7.2295+-	.8118	47.714+-	5.358	3.311+-	.373
TI	.6584+-	.0358	4.345+-	.236	.302+-	.017
V	.0473+-	.0085	.312+-	.056	.022+-	.004
CR	.0663+-	.0051	.438+	.034	-+030+-	.002
MN	.1522+-	.0092	1.005+-	.061	.070+-	.004
FE	12.3051+-	.6217	81.214+-	4.103	5.636+-	.287
NI	.0706+-	.0054	- 466+-	.036	.032+-	.002
CN	3.2137+ <del>-</del>	.1642	21.210+-	1.084	1.472+-	.076
ZN	1.0465+-	.0560	6.907+-	.370	. 479+-	.026
GA	.0294+-	.0092	- 194+-	.061	.013+-	.004
AS .	31.5525+-	1.5993	208.246+-	10.555	14.452+-	.739
SE	.2748+-	.0236	1.827+-	. 156	.127+-	.011
BR	.0000+-	.1515	-000+-	1.000	.000+-	.069
RB	-+0000+-	.0411	-000+-	.271	-+000+-	.019
SR	.0000+-	.0043	-000+-	.028	.000+-	.002
Y	-+0000+-	.0139	.000+-	.092	-+000+-	.004
ZR	.0037+-	.0147	.024+-	.097	.002+-	.007
MO	.0235+-	.0100	.155+-	.066	.011+-	.005
PD	.0000+-	.0275	.000+-	.182	-+000+-	.013
AG	.0852+-	.0181	.562+-	.119	.039+-	.008
CD	.0737+-	.0180	. 486+-	.119	.034+-	.008
IN	-+0000+-	.0198	.000+-	.131	-000+-	.009
SN	.1854+-	.0258	1.224+-	.170	.085+~	.012
SB	3.3673+ <del>-</del>	.2287	22.224+-	1.509	1.542+-	.105
BA	-1011+-	.0859	.667+-	.567	.046+-	.039
LA	.0317+-	. 1531	.209+-	1.010	.015+-	.070
HG	1.1708+-	.3158	7.727+-	2.084	.536+-	. 145
PB	2.6437+-	1367	17.448+-	.902	1.211+-	.063

#### 199/20-004 PROTOCOL:

SAMPLE ID: NEA-017 PARTICLE SIZE: C ANALYSIS ID: MM936

GODFREY ROASTER - CENTER AREA

EXPOSED AREA: 6.60 SQUARE CM MASS OF DEPOSIT: 1313.+- 10. MICROGRAMS

ELEMEN.	r ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	3.3649+-	.4705	22.208+-	3.105	1.691+-	.237
SI	18.3895+-	2.5808	121.371+-	17.033	9.244+-	1.299
₽	.1952+-	.0446	1.288+-	.295	.098+-	.022
S -	1.9588+-	. 2969	12.928+-	1.960	.985+-	.149
CL-	.0000+-	.1409	.000+-	.930	.000+-	.071
· K	.9462+-	.1098	6.245+-	.725	. 476+-	. 055
CA	5.2231+-	<b>.</b> 5871	34.472+-	3.875	2.625+-	. 296
TI -	.4784+-	.0267	3.157+-	.176	.240+-	.014
V	.0450+-	.0069.	.297+-	.046	.023+-	.003
CR	.0448+-	1.0039	.296+-	. 026	.023+~	.002
MN	.0991+-	.0064	- 654+-	.042	.050+-	.003
FE	10.5570+-	.5339	69.676+-	3.524	5.307+-	.271 -
NI	.0623+-	.0050	.411+-	.033	.031+-	.003
CU	2.2330+-	.1146	14.738+-	.756	1.122+-	.058
ZN	.4461+-	.0259	2.944+-	.171	.224+-	.013
GA	.0397+-	.0071	.262+-	.047	.020+-	.004
AS	48.1633+-	2.4333	317.878+-	16.060	24.210+-	1.237
SE	.1693+-	.0199	1.117+-	.131	.085+-	.010
BR	.1430+-	.2199	.944+-	1.451	.072+-	.111
RB	.0000+-	<i>。</i> 0597	.000+-	.394	- 000+-	.030
SR	-0000+-	.0570	-000+-	.376	+000+-	.029
Υ	.0000+-	.0162	.000+-	.107	.000+-	.008
ZŔ	-0169+-	.0136	-112+-	.090	.008+-	.007
MO	-0365+-	.0093	.241+-	.061	.018+-	.005
PD	-+0000+-	.0497	.000+-	.328	.000+-	.025
AG	.0000+-	.0253	-000+-	. 167	.000+-	-013
CD	.0405+-	.0183	.267+-	.121	.020+-	-009
IN	.0000+-	.0167	.000+-	.110	.000+-	.008
SN	.0000+-	.0239	.000+-	. 158	.000+-	.012
SB	3.1976+-	.2347	21.104+-	1.549	1.607+-	.119
BA	-1940+-	.0833	1.280+-	.550	.098+-	.042
LA	- 1466+-	.1450	.968+-	. 957	.074+-	.073
HG	.9806+-	.3002	6.472+-	1.981	. 493+-	. 151
PB	1.8717+-	.0975	12.353+-	. 643	. 941+-	.050

SAMPLE ID: NEA-018 PARTICLE SIZE: C ANALYSIS ID: MN376 ENGINEERING WAREHOUSE

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 624.+- 10. MICROGRAMS

ELEMENT UG/CM2		M2	UG/FILTER		PERCENT	
AL	3.5250+-	. 4679	23.265+-	3.088	3.728+-	. 498
SI	11.9624+-	1.6802	78.952+-	11.089	12.653+-	1.789
F	.1251+-	.0289	.826+-	.191	.132+-	.031
s	.7959+-	.1751	5.253+-	1.155	.842+-	.186
CL	.0039+-	.0305	.026+-	.202	.004+-	.032
K	.6416+-	.0753	4.235+-	- 497	.679+-	.080
CA	2.5185+-	.2841	16.622+-	1.875	2.664+-	.304
ΤI	.3514+-	.0203	2.319+-	.134	.372+-	.022
V	.0416+-	.0058	.275+-	.038	.044+-	.006
CR	.0387+-	.0036	. 255+-	.024	.041+-	.004
MN	-0833+-	.0057	.550+-	.038	.088+-	.006
FE	5.7280+-	.2911	37.805+-	1.921	6.058+-	.323
NI	.0376+-	.0037	.248+-	.024	.040+-	.004
<u> </u>	1.5990+-	.0826	10.553+-	.545	1.691+-	.091
ZN	.4305+-	.0243	2.841+-	.160	. 455+-	.027
GA	.0099+-	.0054	.065+-	.036	.010+-	.006
AS	8.3506+-	.4298	55.114+-	2.837	8.832+-	. 476
SE	.1454+-	.0087	-960+-	.057	.154+-	.010
8R	.0795+-	.0417	.525+-	.275	.084+-	.044
RB	-+0000+-	.0114	-000+-	.075	.000+-	.012
SR	.0339+-	.0035	.224+-	.023	.036+-	.004
Y	.0259+-	.0067	.171+-	.044	.027+-	.007
ZR	.0000+-	.0150	-000+-	.099	.000+-	.016
MO	-+0000+-	.0095	.000+-	.063	.000+-	.010
מפ	.0000+-	.0115	.000+-	.076	.000+-	.012
AG	-+0000+-	.0137	.000+-	.090	.000+-	.014
CD	.0648+-	.0171	. 428+-	.113	.069+-	.018
IN	-0293+-	.0203	.193+-	.134	.031+-	.021
SN	.0000+-	.0249	.000+-	.164	.000+-	.026
SB	.7095+-	.0852	4.683+-	.562	.750+-	.091
BA	.0000+-	.0927	.000+-	.612	.000+-	.098
LA	-+0000+-	.1668	.000+-	1.101	.000+-	. 176
HG	.5270+-	.1067	3.478+-	.704	.557+-	.113
PB	1.4804+-	्_•्0777	9.771+-	.513	1.566+-	.086

SAMPLE ID: NEA-019 PARTICLE SIZE: C ANALYSIS ID: MM924 N. COOLING POND

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 2610.+- 10. MICROGRAMS

ELEMEN	T UG/C	M2	UG/FIL	TER	PERCE	NT ILI
AL	21.9904+-	2.9034	145.137+-	19.162	5.561+-	.735
SI	55.7467+-	7.8260	367.928+-	51.652	14.097+-	1.980
F.	5.0801+-	1.1372	33.529+-	7.505	1.285+-	.288
S	1.5310+-	.2625	10.105+-	1.732	.387+-	.066
CL	-+0000+-	.2765	.000+-	1.825	.000+-	.070
K 1	2.9466+-	.3344	19.448+-	2.207	.745+-	.085
CA	14.4946+-	1.6256	95.664+-	10.729	3.665+-	.411
TI	1.1104+-	.0839	7.329+-	.554	.281+-	.021
V	.0902+-	.0276	.595+-	.182	.023+-	.007
CR -	.1905+-	.0118	1.257+-	.078	.048+-	.003
MN	.1980+-	.0118	1.307+-	.078	.050+-	.003
FE	14.8929+-	.7518	98.293+-	4.962	3.766+-	.191
NI	-+0860+-	.0063	.568+-	.042	.022+-	.002
CN	5.5213+-	.2807	36.441+-	1.853	1.396+-	.071
ZN	.2578+-	.0273	1.701+-	.180	.065+-	.007
GA	.0000+-	.0062	.000+-	.041	.000+-	.002
AS	8.8304+-	.4555	58.281+-	3.006	2.233+-	.116
SE	.1423+-	.0117	.939+-	.077	-036+-	.003
BR	.1375+-	.0467	.908+-	.308	.035+-	.012
₽B	-0000+-	.0129	.000+-	.085	.000+-	.003
SR	.0855+-	.0077	.564+-	.051	.022+-	.002
Y	.0000+-	.0077	.000+-	.051	.000+-	.002
ZR	-+0000+-	.0184	.000+-	.121	.000+-	.005
MO	-0000+-	.0113	.000+-	.075	.000+-	.003
PD	-+0000+-	.0135	-000+-	.089	.000+-	.003
AG	.1066+-	.0194	.704+-	.128	.027+-	.005
CD	.0000+-	.0179	.000+-	.118	.000+-	.005
IN	-+0000+-	.0222	.000+-	. 147	.000+-	.006
SN	.2019+-	.0289	1.333+-	- 191	.051+-	.007
SB	.5359+-	.0742	3.537+-	. 490	.136+-	.019
BA	2.4471+-	.2131	16.151+-	1.406	.619+-	.054
LA	.1337+-	.1939	.882+-	1,280	.034+-	.049
HG	.5473+-	.1389	3.612+-	.917	.138+-	.035
PB	1.6751+-	.0876	11.056+-	.578	.424+-	.022

SAMPLE ID: NEA-020 PARTICLE SIZE: C ANALYSIS ID: MM926

COOLING POND

EXPOSED AREA: 6.60 SQUARE CM

MASS OF DEPOSIT: 1486.+- 10. MICROGRAMS

ELEMENT	ELEMENT UG/CM2		UG/FIL	UG/FILTER		PERCENT	
AL	19.8819+-	2.6246	131.220+-	17.322	8.830+-	1.167	
SI	26.9995+-	3.7910	178.198+-	25.021	11.992+-	1.686	
P	5.1403+-	1.1506	33.926+-	7.594	2.283+-	.511	
S	.9767+	. 1774	6.446+-	1.171	.434+-	.079	
CL	.0000+-	.1992	-+000+-	1.315	.000+-	.088	
K	1.8926+-	.2164	12.491+-	1.428	.841+-	.096	
CA	13.1541+-	1.4755	86.817+-	9.738	5.842+-	. 556	
TI	.6313+-	.0498	4.167+-	.329	.280+-	.022	
V	.0657+-	.0169	. 434+-	.112	.029+-	.008	
CR	.1747+-	.0107	1.153+-	.071	.078+-	.005	
MN	.1364+-	.0088	. 900+-	.058	.061+-	.004	
FE	7.8626+-	.3984	51.893+-	2.629	3.492+-	.179	
NI	.0725+-	.0057	.479+-	.038	.032+-	.003	
CU	6.2340+-	.3167	41.144+-	2.090	2.769+-	.142	
ZN	.1450+ <del>-</del>	.0274	. 957+-	.181	.064+-	.012	
GA	.0000+-	.0048	.000+-	.032	-+000+-	.002	
AS	1.8653+-	.1150	12.311+-	.759	.828+-	.051	
SE	.0631+-	.0059	.416+-	.039	.028+-	.003	
BR	.0296+-	.0108	.195+-	.071	.013+-	.005	
RB	.0000+-	.0041	.000+-	.027	.000+-	.002	
SR	.1102+-	.0079	.727+-	.052	.049+-	.004	
Y	.0000+-	.0061	.000+-	.040	.000+-	.003	
ZR	-+0000+-	.0195	.000+-	. 129	-+000+-	.009	
MO	-+0000+-	.0119	-000+-	.079	-+000	.005	
PD	.0177+-	.0130	117+-	.086	-008+-	.006	
AG	.0721+-	.0188	. 476+-	.124	.032+~	.008	
CD	-+0000+-	.0194	-000+-	.128	.000+-	.009	
IN	.0000+~	.0252	.000+-	-166	.000+-	.011	
SN	.0522+-	.0299	.345+-	.197	.023+-	.013	
SB	.1731+-	.0679	1.142+-	. 448	.077+-	.030	
BA	.6859+-	.1391	4.527+-	.918	.305+-	.062	
LA	-+0000+-	.2051	.000+-	1.354	.000+-	.091	
HG	.1120+-	.0322	.739+-	.213	.050+-	.014	
PB	1.2043+-	0639	7.948+-	.422	.535+-	.029	

SAMPLE ID: NEA-021 PARTICLE SIZE: C ANALYSIS ID: MM938

PARKING LOT N. OF ADMINISTRATION BUILDING

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 517.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FILTER		PERCENT	
AL	4.5726+-	.6051	30.179+-	3.994	5.837+-	.781
SI	13.9494+-	1.9579	92.066+-	12.922	17.808+-	2.523
P	.5247+-	.1179	3.463+-	.778	.670+-	. 151
s	.5558+-	.1297	3.668+-	.856	.710+-	.166
CL	.0438+-	.0255	.289+-	.168	.056+-	.033
K	.6819+-	.0796	4.501+-	.526	.871+-	.103
CA	1.9614+-	.2217	12.945+-	1.463	2.504+-	.287
TI	.3702+-	.0212	2.443+-	.140	. 473+-	.029
V	.0378+-	.0058	.249+-	.038	.048+-	.007
CR	.0578+-	.0045	.381+-	.030	. 074 <del>+-</del>	.006
MN	.0781+-	.0054	.515+-	.036	.100+-	.007
FE	4.5721+-	.2330	30.176+-	1.538	5.837+-	.318
NI	.0506+-	.0043	· <b>.</b> 334 <del>+-</del>	.028	.065+-	.006
CU	1.6913+-	.0872	11.163+-	.576	2.159+-	.119
ZN	.1241+-	.0108	<b>-819+-</b>	.071	.158+-	.014
GA	.0080+-	.0040	.053+-	.026	.010+-	.005
AS	1.3513+-	.0881	8.919+-	.581	1.725+-	.117
SE	.0185+-	.0025	.122+-	.016	.024+-	.003
BR	.0000+-	.0082	.000+-	.054	.000+-	.010
RB	.0000+-	.0030	-000+-	.020	.000+-	.004
SR	-+0000+-	.0030	.000+-	.020	.000+-	.004
Y	-0000+-	.0047	.000+-	.031	.000+-	.006
ZR	.0000+-	.0123	.000+~	.081	.000+-	.016
MD	.0000+-	.0081	-000+-	.053	.000+-	.010
PD	.0134+-	.0090	.088+~	.059	.017+-	.011
AG	.0238+-	.0119	. 157+~	.079	.030+-	.015
CD	-0216+-	.0126	.143+~	.083	.028+-	.016
IN	.0000+-	.0175	.000+-	.115	.000+-	.022
'SN	.0132+-	.0197	.087+~	.130	.017+-	.025
SB	<b>.</b> 0473+-	.0455	.312+~	.300	.060+-	.058
BA	.1700+-	.0850	1.122+~	.561	.217+-	.109
LA	.3060+-	.1530	2.020+~	1.010	.391+-	.195
HG	.0268+-	.0122	. 177+-	.081	.034+-	.016
PB	1.0123+-	0540	6-681+-	.356	1.292+-	.073

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SAMPLE ID: NEA-022 PARTICLE SIZE: C ANALYSIS ID: MM928

ROADWAY N. OF POWER HOUSE

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 829.+- 10. MICROGRAMS

ELEMENT	uG/C	M2	UG/FIL	TER	PERCE	ENT
AL	4.1536+-	.5501	27.413+-	3.631	3.307+-	440
SI	14.0962+-	1.9797	93.035+-	13.066	11.223+-	1.582
F	.6299+-	.1424	4.157+-	.940	.501+-	. 114
S	1.6949+-	.2302	11.186+-	1.519	1.349+-	.184
CL	.0000+-	.3084	.000+-	2.035	.000+-	. 246
ĸ	.6304+-	.0779	4.160+-	.514	.502+-	.062
CA	15.4016+-	1.7271	101.650+-	11.399	12.262+-	1.383
TI	.3003+-	.0177	1.982+-	.117	.239+-	.014
V	.0296+-	.0050	.195+-	.033	.024+-	.004
CR	.0544+-	.0043	.359+-	.028	.043+-	.003
MM	.0734+-	.0052	.484+-	.034	.058+-	.004
FE	6.4690+-	.3284	42.695+-	2.167	5.150+-	.269
NI	.0713+-	.0055	.471+-	.036	.057+-	.004
CN	3.5692+-	.1821	23.557+-	1.202	2.842+-	.149
ZN	.2974+-	.0224	1.963+-	.148	.237+-	.018
GA	-+0000+-	-0044	.000+-	.029	.000+-	.004
AS	2.4465+-	.1371	16.147+-	.905.	1.948+-	.112
SE	.0183+-	.0036	.121+-	.024	.015+-	.003
BR	.0059+-	.0121	.039+-	.080	.005+-	.010
RB	.0000+-	.0040	-+000+-	.026	.000+-	.003
SR	.0361+-	.0039	.238+-	.026	.029+-	.003
Y	.0000+-	.0052	.000+-	.034	.000++	.004
ZR	.0000+-	.0138	-000+-	.091	-+000+-	.011
MO	.0000+ <del>-</del>	.0099	-000+-	.065	.000+-	.008
PD	.0185+-	.0100	.122+-	.066	.015+-	.008
AG	.0398+ <del>-</del>	.0149	.263+-	.098	.032+-	.012
CD	.0562+-	.0160	.371+-	.106	.045+-	.013
IN	-+0000+-	.0188	-000+-	.124	.000+-	.015
SN	.0474+-	.0237	.313+-	.156	.038+-	.019
SB	2.0006+-	.1670	13.204+-	1.102	1.593+-	.134
BA	.1101+-	.0873	.727+-	.576	.088+-	.070
LA	.0366+-	.1553	.242+-	1.025	.029+-	.124
HG	.0576+-	.0210	-380+-	.139	.046+-	.017
PB	1.0695+-	. 0569	7.059+-	.376	.851+-	.046

SAMPLE ID: NEA-001
PARTICLE SIZE: T
ANALYSIS ID: MM963
N. SIDE OF STORAGE TANKS
EXPOSED AREA: 12.80 SQUARE CM
MASS OF DEPOSIT: 1566.+- 10. MICROGRAMS

PARTICLE SIZE

	· ·- ·						
ELEMENT	ne/ci	M2 _	UG/FIL	TER	PERCE	PERCENT	
AL	1.9402+-	.2588	24.835+-	3.312	1.586+-	.212	
SI	7.7932+-	1.0951	99.753+-	14.017	6.370+~	.896	
₽	.1256+-	.0289	1.608+-	.370	.103+-	.024	
S	2.0178+-	. 2905	25.828+-	3.718	1.649+~	. 238	
CL	.0152+-	.0347	.195+-	. 444	.012+-	.028	
K	.3909+~	.0473	5.003+-	. 605	.319+~	.039	
CA	2,7437+-	.3093	35.119+-	3.959	2.243+-	.253	
TI	.2235+-	.0137	2.861+-	.175	.183+~	.011	
V	.0328+-	.0045	.420+-	.058	.027+-	.004	
CR	.0707+-	.0052	.905+-	. 067	.058+~	.004	
MN	·.0763+-	.0054	.977+-	- 069	.062+-	.004	
FE	11.3008+-	.5713	144.650+-	7.313	9.237+-	.471	
NI	.0480+-	.0042	-614+-	.054	.039+-	.003	
CU	5.5942+-	. 2844	71.606+-	3.640	4.573+~	. 234	
ZN	.3832+-	.0313	4.905+-	.401	.313+-	.026	
GA	.0000+-	.0062	.000+-	.079	.000+~	.005	
AS	2.5582+-	.1597	32.745+-	2.044	2.091+-	.131	
SE .	-+0000+-	.0027	.000+-	.035	-+000+~	.002	
BR	-0000+-	.0123	-000+-	. 157	.000+-	.010	
RB	.0000+-	.0039	.000+-	.050	.000+-	.003	
SR	.0156+-	.0026	.200+-	.033	.013+-	.002	
Y	.0000+-	.0067	.000+-	.086	.000+-	.005	
ZŖ	.0000+-	.0123	-000+-	. 157	.000+-	.010	
MO	.0459+-	. 0091	.588+-	-116	.038+-	.007	
PD	-0000+-	.0089	-000+-	-114	.000+ <del>-</del>	.007	
AG	.0000+-	.0112	.000+-	143	000+	.009	
CD	.0000+-	.0134	-000+-	.172	.000+-	.011	
IN	.0000+-	.0169	.000+-	.216	-000+-	.014	
·SN	.0785+-	. 0227	1.005+-	. 291	.064+-	.019	
SB,	. 2648+-	. 0527	3.389+-	. 675	.216+-	.043	
BA	1113+-	.0775	1.425+-	992	.071+-	. 063	
LA	<b>**0000+</b> -	.1349	.000+-	1.727	.000+-	.110	
HG	.0000+-	.0098	-000+-	. 125	-000+-	.008	
PB	1.7367+-	. 0907	22.230+-	1.161	1.420+-	.075	
	5.5						

SAMPLE ID: NEA-002 PARTICLE SIZE: T ANALYSIS ID: MM965

N. SIDE OF PLATE TREATER

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 2892.+- 10. MICROGRAMS

ELEMENT	ug/ci	M2	UG/FIL	TER	FERCE	NT
AL	2.7020+-	.3617	34.586+-	4.629	1.196+-	.160
SI	11.6302+-	1.6338	148.867+-	· · -	5.148+-	.723
6 21	.2978+-	.0689	3.811+-	.882	.132+-	.030
S	2.3657+-	1.1207	30.280+-		1.047+-	.496
SL CL	.0000+-	.1843	.000+-	2.340	.000+-	.082
K	.6131+-	.0761	7.847+-	.974	.271+-	.034
CA	14.4634+-	1.6221	185.131+-		6.401+-	.718
TI	.4227+-	.0239	5.411+-	.306	.187+-	.011
V	.0487+-	.0067	.623+-	.086	.022+-	.003
ČR	.1739+-	.0105	2.225+-	.134	.077+-	.005
MN	.1708+-	.0104	2.186+-	.133	.076+-	.005
FE	25.8459+-	1.3034	331.084+-		11.448+-	.578
NI	.1441+-	.0093	1.844+-	.119	.064+-	.004
CU	14.8156+-	.7502	189.640+-	9.403	6.557+~	.333
ZN	.9839+-	.0793	12.594+-	1.015	.435+-	.035
GA	.0435+-	.0345	.557+-	.442	.019+-	.015
AS	9.1920+-	7482	117.658+-	9.577	4.068+-	.331
SE	.0000+-	.0081	-000+-	.104		.004
BR	.0000+-	.0413	.000+-	.529	.000+-	.018
RB	.0000+-	.0122	.000+-		.000+-	.005
SR	.0237+-	.0057	.303+-	.073	.010+-	.003
Y	.0000+-	.0367	.000+-	.470	.000+-	.016
ZR	.0000+-	.0241	.000+-	.308	.000+-	.011
MO	.0853+-	.0134	1.092+-	.172	.038+~	.006
PD	-0000+-	.0179	.000+-	. 229	.000+-	.008
AG	.1536+-	.0204	1.966+-	.261	.068+-	.009
CD	. <del>1</del> 584+-	.0243	2.028+-	.311	.070+-	.011
IN	.0000+-	.0238	.000+-	.305	.000+-	.011
SN	.3509+-	.0374	4.492+-	. 479	.155+-	.017
SB	1.3487+-	.1258	17.263+-	1.610	.597+-	.056
BA	.1767+-	.1071	2.262+-	1.371	.078+-	.047
LA	.3071+-	.1943	3.931+-	2.487	.136+-	.086
HG	.0462+-	.0231	.591+-	. 296	.020+-	.010
PB	11.1345+-	.5675	142.522+-	7.264	4.928+-	.252

SAMPLE ID: NEA-003 PARTICLE SIZE: T ANALYSIS ID: MM953 REVERB FURNACE

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 9742.+- 10. MICROGRAMS

ELEME	NT UG/C	M2	UG/FI	_TER	PERCE	NT _=
AL	9.9592+~	1,4132	127.478+-	18.090	1.309+-	. 186
SI	40.1009+-	5.6305	513.292+-	72.071	5.269+-	.740
P	1.8951+-	. 4254	24.257+-	5.445	.249+-	.056
S	24.4934+-	4.4641	313.515+-	57.141	3.218+-	.587
CL	.0000+-	.5667	.000+-	7.254	.000+-	.074
K,	2.9228+-	.3341	37.412+-	4.277	.384+~	.044
CA	16.3518+-	1.8339	209.303+-	23.474	2.148+-	.241
TI	1.4294+-	.0825	18.296+-	1.056	.188+-	.011
V	.2227+-	.0245	2.851+-	.314	.029+-	.003
CR	. 9777+-	.0512	12.515+-	. 655	.128+-	.007
MN	.7261+-	.0397	9.294+-	.508	.095+-	.005
FΕ	127.7862+-	6.4267	1635.663+-	82.262	16.790+~	.845
NI	.8295+-	.0442	10.618+-	. 566	.109+-	.006
CU	109.0396+-	5.5096	1395.707+-	70.523	14.327+-	.724
ZN	8.4275+-	.6130	107.872+-		1.107+-	.081
GA	-+0000+-	.0835	.000÷-	1.069	.000+-	.011
AS	65.1726+-	3.5792	834.209+~	45.814	8.563+-	.470
SE	.0655+-	.0336	.838+-	.430	.009+-	.004
BR	.0000+-	. 2754	.000+-		.000+-	.036
RB	-0000+-	.0754	-000+-		.000+-	.010
SR	.0236+-	.0118	.302+-	.151	-003+-	.002
Υ	.0000+-	.0892	.000+-		.000+-	.012
ZŔ	.0395+-	.0468	.506+-	.579	.005+-	.006
MO	4739+-	.0406	6.066+-	·	.062+-	.005
PD	. 0000+-	.1243	-000+-	1.591	.000+-	.016
AG	- 4476+-	.0816	5.729+-	1.044	.059+-	.011
CD	.5193+-	.0815	6.647+-		.068+-	.011
IN	.1687+-	.0398	2.159+-	.509	.022+-	.005
SN	1.5160+-	.1105	19.405+-		. 199+-	.015
SB	9.9948+-	.6018	127.933+-		1.313+-	- 079
BA	.7158+-	.1334	9.162+-	1.708	.094+-	.018
LA	-0000+-	1972		2.524	.000+-	.026
HG	.3592+-	.1796	4.598+-	2.299	.047+-	.024
PB	26.8241+-	1.3637	343.348+-	17.455	3.524+-	. 179

SAMPLE ID: NEA-004
PARTICLE SIZE: T
ANALYSIS ID: MM954
REFINERY #1 - N.W. END

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 3433.+- 10. MICROGRAMS

ELEMEN	T UG/C	M2	UG/FIL	_TER	PERCE	ENT
AL	3.0805+-	.4101	39.430+-	5.250	1.149+-	.153
SI	10.4456+-	1.4675	133.703+-	18.784	3.895+-	.547
P	.2603+-	.0823	3.332+-	1.053	.097+~	.031
S	8.3461+-	.9856	106.830+-	12.615	3.112+-	.368
CL	.0000+-	.5946	-+000+-	7.611	.000+~	.222
K	.3938+-	.0955	5.041+-	1.223	.147+-	.036
CA	56.4915+-	6.3296	723.092+-	81.019	21.063+-	2.361
TI	.2764+-	.0165	3.53 <b>8+-</b>	.211	.103+-	.006
V	.0245+-	.0046	.314+-	.059	.009÷-	.002
CR	.0587+-	.0046	.751+-	.059	.022+-	.002
MN	.0818+-	.0057	1.047+-	.073	.030+-	.002
FE	9.0871+-	. 4600	116.315+-	5.888	3.388+-	.172
NI	.2084+-	.0126	2.668+-	.161	.078÷-	.005
CU	5.4546+-	.2773	69.819+ <del>-</del>	3.549	2.034+-	.104
ZN	.5738+-	.0381	7.345+-	. 488	.214+-	.014
GA	-0155+-	.0092	.198+-	.118	.006+-	.003
AS	5.3578+-	.3079	<b>68.580+-</b>	3.941	1.998+-	.115
SE	.0022+-	.0040	.028+-	.051	.001+-	.001
BR	.0000+-	.0256	- 000+-	.328	.000+-	.010
RB	-+0000+-	.0073	000+-	.093	-+000	.003
SR	.0976+-	.0062	1.249+-	.079	.036+-	.002
Y	-+0000+-	.0101	-000+-	.129	-+000+-	.004
ZR	.0000+-	.0149	.000+-	.191	-000+-	.006
MO	.0537+ <del>-</del>	.0104	. 687+-	.133	.020+-	.004
PD	.0000+-	.0112	.000+-	.143	-000+-	.004
AG	-+0000+-	.0192	.000+-	.246	-+000+-	.007
CD	-+0000+-	.0167	-000+-	.214	-000+-	.006
IN	-+0000+-	.0184	.000+-	.236	-000+-	.007
SN	-+0000+-	.0246	.000+-	.315	.000+-	.009
SB	1.5274+-	.1348	19.551+-	1.725	.569+-	.050
BA	<u>, 1076+-</u>	.0842	1.377+-	1.078	.040+-	.031
LA	. 2377+-	. 1543	3.043+-	1.975	.087+-	.058
HG	•0000 <del>+-</del>	.0119	.000+-	.152	-000+-	.004
PB	2.7420+-	1417	35.098+-	1.814	1.022+-	.053

SAMPLE ID: NEA-004
PARTICLE SIZE: T
ANALYSIS ID: MM955
REFINERY #1 - N.W. END

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 6525.+- 10. MICROGRAMS



			•				
ELEMEN	NT UG/0	CM2	M2 UG/FILTER			PERCENT	
AL	4.6707+-	.6214	59.785+-	7.954	.916+-	.122	
SI	15.2673+-	2.1446	195.421+-	27.451	2.995+-	.421	
F'	.3166+-	.1289	4.052+-	1.650	.062+-	.025	
S ·-	11.8317+-	1.3972	151.445+-	17.884	2.321+-	. 274	
CL	.0000+-	.1055	.000+-	1.351	.000+-	.021	
K	.5067+-	.1592	6.485+-	2.038	.099+-	.031	
CA	101.7108+-	11.3947	1301.898+-1	45.852	19.952+-	2.235	
TI	.3837+-	.0219	4.911+-	.280	.075+-	.004	
V	.0435+-	.0062	. 557+-	.079	.009+-	001	
CR	.0822+-	.0058	1.052+-	.074	.016+-	.001	
MN	.1122+-	.0073	1.436+-	.093	.022+-	.001	
FE	13.8727+-	.7005	177.571+-	8.966	2.721+-	.137	
NI	.3120+-	.0179	3.994+-	. 229	.061+-	.004	
CU	7.8383+-	.3978	100.330+-	5.092	1.538+-	.078	
ZN	.8717+-	.0559	11.158+-	.716	. 171+-	.011	
GA	.0000+-	.0123	-000+-	. 157	.000+-	.002	
AS	7.5225+-	.4290	96.288+-	5.491	1.476+-	.084	
SE	.0000+-	.0049	-+000+-	.063	.000+-	.001	
BR	.0000+-	.0350	.000+-	.448	.000+-	.007	
RB	-+0000+-	-0099	.000+-	.127	.000+-	.002	
SR	.1858+-	.0105	2.378+-	.134	.036+−	.002	
Υ .	-+0000+-	.0133	-000+-	.170	.000+-	.003	
ZR	-0000+-	.0189	.000+-	.242	.000+-	.004	
MO	.0622+-	.0118	.796+-	.151	.012+-	.002	
PD	.0000+-	.0141	.000+-	.180	.000+-	.003	
AG	.2046+-	.0257	2.619+-	.329	.040+-	.005	
CD	.0516+-	.0220	-+060+-	.282	.010+-	.004	
IN	-0000+-	.0201	.000+-	. 257	.000+-	.004	
SN	.1732+-	.0289	2.217+-	. 370	.034+	.006	
: SB	2.8046+-	.1867	35.899+-	2.390	.550+-	. 037	
BA	. 1444+-	.0952	1.848+-	1.219	.028+-	.019	
LA	.3397+-	1749	4.348+-	2.239	.067+-	.034	
HG	-+0000+-	.0168	.000+-	.215	.000+-	.003	
PB	3.7402+-	1923	47.875+-	2.461	.734+-	.038	

SAMPLE ID: NEA-005 PARTICLE SIZE: T ANALYSIS ID: MM970 S. END OF REFINERY #3

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 1037.+- 10. MICROGRAMS

ELEMEN	r ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	3.9097+-	.5182	50.044+-	6.633	4.825+-	- 641
SI	10.1461+-	1.4252	129.871+-	18.243	12.524+-	1.763
F	.1932+-	.0442	2.473+-	.566	.238+-	.055
S	1.4600+-	.2104	18.688+-	2.693	1.802+-	.260
CL	.0618+~	.0300	.791+-	.385	.076+-	.037
K	.4393+-	.0532	5.623+-	.681	.542+-	.066
CA	4.3764+-	- 4922	56.018+-	6.300	5.402+-	.610
ΤI	.2916+-	.0173	3.732+-	.221	.360+-	.022
V	.0294+-	.0050	. 376+-	.064	.036+-	.006
CR	.0562+-	.0046	.719+-	.059	.069+-	.006
MN	.0726+-	.0054	.929+-	.069	.090+-	.007
FE	5.7834+-	.2939	74.028+-	3.762	7.139+-	.369
NI	.1901+-	.0117	2.433+-	.150	.235+-	.015
CU	3.6875+-	.1881	47.200+-	2.408	4,552+-	.236
ZN	.2455+-	.0210	3.142+-	.269	.303+-	.026
GA	-+0000+-	.0045	-+000+-	.058	.000+-	.006
AS	2.0839+-	.1223	26.674+-	1.565	2.572+-	.153
SE	.0144+-	.0031	.184+-	.040	.018+-	.004
BR	.0000+	.0104	.000+-	. 133	.000+-	.013
RB	.0000+-	.0041	-+000+-	:052	. 000+-	.005
SR	.0137+-	.0038	.175+-	-049	.017+-	.005
Y	.0000+-	.0058	-000+-	.074	.000+-	.007
ZR	.0000+-	.0163	.000+-	.209	.000+-	.020
MO	.0000+-	.0122	.000+-	. 156	.000+-	.015
PD	-+0000+-	.0115	.000+-	.147	.000+-	.014
AG	.1302+-	.0198	1.667+-	. 253	··.161+-	.024
CD	.0275+-	.0179	.352+-	.229	.034+-	.022
IN	.0239+-	.0236	.306+-	.302	.030+-	.029
SN	.0629+-	.0293	.805+-	375	.078+-	.036
SB	.7170+-	.0916	9.178+-	1.172	.885+-	.113
BA	.0000+-	.1102	.000+-	1.411	.000+-	.136
LA	.1187+-	.2070	1.519+-	2.650	.147+-	. 256
HG	-+0000+-	.0083	.000+-	.106	.000+-	.010
PB	1.1283+-	.0601	14.442+-	.769	1.393+-	.075

SAMPLE ID: NEA-006 PARTICLE SIZE: T ANALYSIS ID: MM971

N. SIDE OF HERSHEKOFF ROASTERS EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 2781.+- 10. MICROGRAMS

ELEMENT UG/CN		M2	M2 UG/FILTER		PERCENT	
AL	3.1418+-	.4195	40.215+-	5.369	1.446+-	.193
SI	9.5139+-	1.3368	121.778+-	17.111	4.379+-	.615
₽	.3561+-	.0812	4.557+-	1.039	.164+-	.037
S	5.0966+-	.7886	65.237+-	10.095	2.346+-	.363
CL	.0426+-	.0956	.546+-	1.223	.020+-	.044
K ¯	.6893+-	.0828	8.824+-	1.060	.317+-	.038
CA	10.9255+-	1.2258	139.846+-	15.690	5.029+-	.564
ΤI	.5344+-	.0295	6.840+-	.378	.246+-	.014
V	-0933+-	.0091	1.194+-	.116	.043+-	. 004
CR	.2011+-	.0119	2.574+-	.152	.093+-	.005
MN	.2765+-	.0157	3.539+-	.201	. 127+-	.007
FE	46.0401+-	2.3175	589.313+-		21.191+-	1.069
NI	.1326+-	.0087	1.697+-	. 111	.061+-	.004
CU	10.9549+-	.5552	140.223+-	7.107	5.042+-	.256
ZN	.8140+-	.0619	10.419+-	.792	.375+-	.029
GA	.0000+-	.0169	.000+-	.216	-+000+-	.008
AS	9.0330+-	.5348	115.622+-	6.845	4.158+-	.247
SE	-+0000+-	.0058	.000+-	.074	.000+-	.003
BR	-0000+-	.0403	-+000+-	.516	.000+-	.019
RB	.0000+-	.0114	-000+-	.146	-+000+-	.005
SR	.0444+-	.0044	.568+-	.056	.020+-	.002
Y	-0000+-	.0180	.000+-	.230	.000+-	.008
ZR	.0150+-	.0175	.192+-	.224	.007+-	.008
MO	.0917+-	.0134	1.174+-	.172	.042+-	.006
PD	-0000+-	.0140	.000+-	.179	.000+-	.006
AG	-0000+-	.0176	-000+-	.225	.000+-	.008
ED	.0848+-	.0195	1.085+-	.250	.039+-	.009
IN	-0000+-	.0216	-000+-	.276	.000+-	.010
SN	.1953+-	.0333	2.500+-	.426	.090+-	.015
SB	1.2415+-	.1121	15.891+-	1.435	.571+-	.052
BA	.1675+-	. 1033	2.144+-	1.322	.077+-	.048
LA	<i>-</i> 1272+~.	.1841	1.628+-	2.356	.059+-	.085
HG	.0051+-	.0247	.065+-	. 316	.002+-	.011
PB	5.2686+-	2699	67.438+-	3.455	2.425+-	. 125

SAMPLE ID: NEA-007 PARTICLE SIZE: T ANALYSIS ID: MM956 REFINERY #1 - S. END

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 2182.+- 10. MICROGRAMS

ELEMENT	nevc	M2 <sup>.</sup>	UG/FIL	TER ·	PERCE	ENT
AL	2.0371+-	.2731	26.075+-	3.496	1.195+-	.160
SI	8.5141+-	1.1963	108.981+-	15.313	4.995+-	.702
P	.2492+-	.0584	3.189+-	.748	.146+-	.034
S	3.8211+-	.5183	48.910+-	6.634	2.242+-	.304
CL	.0000+-	.2279	.000+-	2.918	.000+-	.134
K	.4670+-	.0611	5.977+-	.782	.274+-	.036
CA	15.4550+-	1.7331	197.824+-	22.184	9.066+~	1.018
TI	.3784+-	.0216	4.844+-	.276	.222+-	.013
V	.0401+-	.0060	.513+-	.077	.024+-	.004
CR	.1186+-	.0076	1.518+-	.097	.070+-	.004
MN	.1215+-	.0078	1.555+-	.100	.071+-	.005
FE	16.1348+-	.8142	206.525+-	10.422	9.465+-	.480
NI	.2402+-	.0142	3.075+-	.182	.141+-	.008
СП	9.3744+-	. 4753	119.992+-	6.084	5.499+ <del>-</del>	.280
ZN	.6581+-	.0519	8.424+-	- 664	.386+-	.030
GA	.0000+-	.0097	-000+-	.124	-+000+-	.006
AS	7.0474+-	.3867	90.207+-	4.950	4.134+-	.228
SE	.0628+-	.0080	.804+-	.102	.037+-	.005
BR	.0143+-	.0327	.183+-	-419	.008+-	.019
RB	-+0000+-	.0091	-000+-	.116	.000+-	.005
SR	.0375+-	.0036	.480+-	.046	.022+-	.002
Ý	.0000+-	<b>-0104</b>	-000+-	.133	.000+-	.006
ZR	.0000+~	.0136	.000+-	. 174	-000+-	.008
MO	.0417+-	• 0099	.534+-	.127	.024+-	.006
PD	.0000+-	.0110	.000+-	.141	.000+-	.006
AG	.4519+ <del>-</del>	.0390	5.784+-	. 499	. 265+-	.023
CD	.0000+-	.0191	-+000	.244	.000+-	.011
IN	-0000+-	.0186	.000+-	.238	.000+-	.011
SN	.0000+-	.0278	-,000+-	.356	.000+-	.016
SB	1.5809+-	. 1353	20.236+-	1.732	.927+-	.079
BA	-1660+-	. 0855	2.125+-	1.094	.097+-	.050
LA	.0000+-	. 1464	.000+-	1.874	-000+-	.086
HG	-+0000+-	.0167	.000+-	.214	.000+-	.010
PB	2.8208+~	1457	36.106+-	1.865	1.655+-	.086

SAMPLE ID: NEA-008 PARTICLE SIZE: T ANALYSIS ID: MM972

CENTRAL CHANGE

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 1195.+- 10. MICROGRAMS

ELEMENT	UG/C	M2	UG/FIL	TER	PERCE	ENT
AL	2.2784+-	.3034	29.164+-	3.884	2.440+-	.326
SI	6.9899+-	.9823	89.470+-	12.574	7.487+-	1.054
F	.1762+-	.0404	2.255+-	.517	.189+-	.043
`S	1.3912+-	.2177	17.808+-	2.786	1.490+-	.233
CL	.0000+-	.1701	.000+-	2.177	.000+-	.182
K	<b>.</b> 3679+-	.0451	4.709+-	. 577	.394+-	.048
·CA	3.6523+-	.4111	46.750+-	5.262	3.912+-	.442
TI	.2490+-	.0151	3.187+-	.193	.267+-	.016
V	.0374+-	.0050	. 479+-	.064	.040+-	.005
CR	.1149+-	.0075	1.471+-	.096	.123+-	.008
MN .	.0724+-	.0055	。927+ <del>-</del>	.070	.078+-	.006
FE	8.3018+-	.4205	106.263+-	5.382	8.872+-	. 457
NI	.1029+-	.0072	1.317+-	.092	.110+-	.008
CU -	7.1597+-	.3635	91.644+-		7.669+-	.395
ZN	.3436+-	.0352	4.398+-	.451	.368+-	.038
GA	.0000+-	.0054	-000+-	.069	.000+-	.006
AS	3.2314+-	.1808	41.362+-	2.314	3.461+-	.196
SE	.0129+-	.0036	.165+-	.046	.014+-	.004
BR	.0000+-	.0152	.000+-	.195	.000+-	.016
RB	-0000+-	.0049	.000+-	.063	.000+-	.005
· SR	.0239+-	.0035	.306+-	.045	.026+-	.004
Y	.0000+-	.0064	-000+-	.082	.000+-	.007
ZR	-0000+-	.0161	.000+~	.206	.000+-	.017
MO	.0230+-	.0115	.294+-	.147	.025+-	.012
PD	-0000+-	.0117	-000+-	.150	.000+-	.013
AG	.0000+-	.0157	-000+-	.201	.000+-	.017
CD	-0000+-	.0167	-000+-	.214	.000+-	.018
IN	-0000+-	.0222	-000+-	-284	-000+-	.024
SN	-0000+-	.0282	-000+-	.361	.000+-	.030
SB	-3305+-	.0710	4.230+-	.909	.354+-	.076
BA	.1377+-	.1049	1.763+-	1.343	.147+-	.112
LA	.0000+-	. 1857	.000+-	2.377	.000+-	.199
HG	-0000+-	.0102	-000+-	.131	.000+-	.011
PB	1.4179+-	.0747	18.149+-	- 956	1.519+-	.081

SAMPLE ID: NEA-009 PARTICLE SIZE: T ANALYSIS ID: MM973 SURFICIAL DUST SAMPLE

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 1029.+- 10. MICROGRAMS

ELEMENT	uG/C	M2	UG/FIL	TER	PERCE	ENT
AL	4.6775+~	.6194	59.872+-	7.929	5.818+~	.773
SI	16.6020+-	2.3312	212.506+-	29.840	20.652+~	2.907
F	.1697+-	.0387	2.172+-	. 496	.211+-	.048
S	1.1259+-	.1811	14.412+-	2.318	1.401+-	.226
CL	.0411+-	.0280	.526+-	.358	.051+~	.035
K	.6480+-	.0760	8.294+-	.972	.806+-	.095
CA	2.4774+-	. 2795	31.711+-	3.578	3.082+-	.349
ΤI	.3435+-	.0199	4.397+-	. 255	.427+-	.025
V	.0303+~	.0054	.388+-	.069	.038+-	.007
CR	.0544+-	.0044	.696+-	.056	.068+-	.006
MN	.0887+-	.0060	1.135+-	.077	.110+-	.008
FE	8.5059+-	.4308	108.876+-	5.514	10.581+-	.546
NI	.0391+-	.0038	.500+-	.049	.049+	.005
CU	1.2128+-	.0631	15.524+-	.808	1.509+-	.080
ZN	.2686+-	.0161	3.438+-	. 206	.334+-	.020
GA	.0052+-	.0045	.067+-	.058	.006+-	.006
AS	2.6707+-	.1500	34.185+-	1.920	3.322+-	.189
SE	.0149+-	.0032	.191+-	.041	.019+-	.004
BR	.0186+-	.0137	.238+-	.175	023+-	.017
RB	.0000+-	.0043	.000+-	.055	.000+-	.005
SR	.0062+-	.0032	.079+-	.041	-008+-	.004
Y	-0000+-	.0055	.000+-	.070	.000+-	.007
ZR	.0000+-	.0152	.000+-	.195	.000+-	.019
MO	•0190 <del>+-</del>	.0095	.243+-	.122	.024+-	.012
. PD	-0000+-	.0093	.000+-	.119	.000+-	.012
AG	.0264+-	.0132	.338+-	.169	•033+~	.016
CD	.0382+-	.0152	. 489+-	.195	.048+-	.019
IN	.0067+-	.0188	.086+-	.241	-008+-	.023
SN	-0490+-	.0245	.627+-	.314	.061+-	.030
SB	:	0592	3.369+-	. 758	.327+-	.074
BA	-1543+-	.0943	1.975+-	1.207	.192+-	.117
LA	-+0000+-	. 1635	.000+-	2.093	.000+-	.203
HG	- 0758+-	.0284	.970+-	. 364	.094+-	. 035
PB	1.1874+-	.0629	15.199+-	.805	1.477+-	.080

SAMPLE ID: NEA-010 PARTICLE SIZE: T ANALYSIS ID: MM974 UPPER STACK AREA

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 703.+- 10. MICROGRAMS

ELEMENT	UG/C	M2	UG/FI	TER	PERCE	ENT
AL _	2.9621+-	.3934	37.914+-	5.035	5.393+-	.720
SI	11.1871+-	1.5713	143.195+-	20.113	20.369+-	2.876
F'	.0823+-	.0193	1.054+-	. 247	.150+-	.035
S	.2863+-	.0605	3.664+-	.775	.521+-	.110
CL	.0000+-	.0617	.000+-	<b>.</b> 789	.000+-	.112
K	.4731+-	.0562	6.055+-	.720	.861+-	.103
CA	1.2190+-	.1386	15.604+-	1.774	2.220+-	.254
TI	.2196+-	.0136	2.811+-	.174	.400+-	.025
V -	.0133+-	.0038	.170+-	.049	.024+-	.007
CR	.0516+-	.0042	.660+-	.054	.094+-	.008
MN	.0593+-	-0046	.759+-	.059	.108+-	.009
FE	3.5717+-	.1827	45.718+-	2.339	6.503+-	.345
NI	.0392+-	.0038	.502+-	. 049	.071+-	.007
CU	.4309+-	.0236	5.516+-	.302	.785+-	.044
ZN	.0645+-	.0053	.826+-	.068	.117+-	.010
GA	.0000+-	.0018	.000+-	.023	.000+-	.003
AS	4.1628+-	.2118	53.284+~	2.711	7.579+-	.400
SE	.0070+-	.0024	.090+-	.031	.013+-	.004
BR	.0000+-	.0201	.000+-	. 257	.000+-	.037
RB	.0000+-	.0058	.000+-	. 074	.000+-	.011
SR	.0000+-	.0029	.000+-	.037	.000+-	.005
Y	.0000+-	.0038	-+000+-	.049	.000+-	.007
ZR .	-+0000+-	.0132	-000+-	.169	.000+-	.024
MO	.0362+-	.0099	463+-	.127	.066+-	.018
PD	.0000+-	.0104		. 133	.000+-	.019
AG	-+0000+-	.0133	.000+-	.170	.000+-	.024
CD	.0000+-	.0148	-000+-	.189	.000+-	.027
IN	.0000+-	.0182	-000+-	.233	.000+-	.033
, SN	-+2850.	.0231	. 493+-	. 296	.070+-	.042
SB	.2412+-	.0571	3.087+-	.731	. 439+-	.104
BA	-0000+-	.0878	.000+-	1.124	.000+-	.160
LA	.0000+-	.1604	.000+-	2.053	.000+-	. 292
HG	<u>-+2660 .</u>	.0226	.851+-	. 289	.121+-	.041
PB	. 2848+ <del>-</del>	.0176	3.645+-	. 225	.519+-	.033

SAMPLE ID: NEA-011 PARTICLE SIZE: T ANALYSIS ID: MM964

N. SIDE - UPPER STACK AREA

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 2067.+- 10. MICROGRAMS

ELEMENT	r ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	6.7723+-	.8959	86.685+-	11.467	4.194+-	. 555
SI	21.8468+-	3.0674	279.639+-	39.262	13.529+-	1.901
F	.2003+-	.0466	2.564+-	.596	.124+-	.029
S	.5721+-	.1793	7.323+-	2.295	.354+-	.111
CL	.0000+-	.1680	.000+-	2.150	-+000+-	.104
K	.9783+ <del>-</del>	.1139	12.522+-	1.457	.606+-	.071
CA	8.8597+-	. 9944	113.404+-	12.728	5.486+-	.616
ΤI	.5876+-	.0322	7.521+-	.412	.364+-	.020
V	.0374+-	.0077	.479+-	.099	.023+-	.005
CR	.0511+-	.0044	.454+-	.056	.032+-	.003
MN	.1289+-	.0081	1.650+-	.104	.080+-	.005
FE	9.5066+-	.4811	121.684+-	6.158	5.887+-	. 299
NI	.0404+-	.0039	.517+-	.050	.025+-	.002
cu	1.2648+-	.0657	16.189+-	.841	.783+-	.041
ZN	.6708+ <del>-</del>	.0358	8.586+-	. 458	.415+-	.022
GA	.0067+-	.0057	.086+-	.073	.004+-	.004
AS	3.2593+-	.1852	41.719+-	2.371	2.018+-	.115
SE	.0116+-	.0034	.148+-	.044	.007+-	.002
BR	.0177+-	.0163	.227+-	.209	.011+-	.010
RB	-+0000+-	.0052	-000+-	.067	.000+-	.003
SR	.0531+-	.0046	.680+-	.059	.033+-	.003
Y	-0000+-	.0068	-+000+-	.087	-+000+-	.004
ZR	-+0000+-	.0164	-+000+-	.210	.000+-	.010
MO	.0000+-	.0115	.000+-	.147	.000+-	.007
PD	-+0000+-	.0125	-000+-	.160	-+000+-	.008
AG	-0000+-	.0150	.000+-	.192	.000+-	.009
CD	.0000+ <del>-</del>	.0175	.000+-	.224	.000+-	.011
IN	-+0000+-	.0224	.000+-	.287	-+000+-	.014
SN	.1721+-	.0292	2.203+-	.374	.107+-	.018
SB	2.0901+-	.1457	26.753+-	1.865	1.294+-	.090
BA	-+0000+-	.1065	-000+-	1.363	-000+-	.066
LA	.0000+-	.1918	.000+-	2.455	.000+-	.119
HG	-0878+-	.0306	1.124+-	.392	.054+-	.019
PB	1.5552+-	.0816	19.907+-	1.044	.963+-	.051

SAMPLE ID: NEA-012 PARTICLE SIZE: T ANALYSIS ID: MM957

N.W. SIDE - UPPER STACK AREA EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 2175.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FIL	_TER	PERCE	ENT [] [
AL	5.5219+-	.7321	70.680+-	9.372	3.250+-	.431
SI	18.9193+-	2.6565	242.167+-	34.004	11.134+-	1.564
P	.3195+-	.0722	4.090+~	.925	.188+-	.043
Ś	.0000+-	.7813	.000+~	10.001	.000+-	.460
CL	.0000+-	.1331	.000+~	1.704	.000+-	.078_
κ -	1.0536+-	.1217	13,487+-	1.558	.620+-	.072
CA	4.5117+-	.5074	57.749+-	6.494	2.655+-	.299
TI	.5103+-	.0283	6.532+~	. 362	.300+-	.017
V	.0437+-	.0071	-,559+-	.091	.026+-	.004
CR	.0472+-	.0040	.604+~	.051	.028+-	.002
MN	-1157+-	.0073	1.481+-	.093	-068+-	.004
FE	12.7499+-	.6441	163.199+-	8.244	7.503+-	.381
NI	.0485+-	.0042	. 621+~	.054	.029+-	.002
ԵՄ	2.2537+-	.1157	28.847+-	1.481	1.326+-	.068
ZN	1.3763+-	.0716	17.617+~	-916	.810+-	.042
GA	.0207+-	.0258	. 265+-	.330	.012+-	.015
AS	10.8136+-	.6992	138.414+-	8.750	6.364+-	.413
SE	-+0000+-	.0072	-+000+~	.092	.000+-	.004
BR	.0000+-	.0518	-+000+-	. 663	.000+-	.030
RB	.0000+-	.0144	-+000	.184	.000+-	.008
SR	.0404+-	.0082	.517+-	.105	.024+-	.005
Y	-0000+-	.0275	-000+~	.352	.000+-	.016
ZR	.0126+-	-0174	.161+-	.223	.007+-	.010
MO	.0000+-	.0078	-+000+-	.100	.000+-	. 005
PD	.0000+-	.0128	.000+-	.164	.000+-	.008
AG	-0000+-	.0126		.161	.000+-	.007
CD	.1473+-	.0206	1.885+~	. 264	.087+-	.012
IN	.0000+-	.0154	-+000+-	. 197	.000+-	.009
SN	. 1144+-	.0276	1.464+-	.353	-067+-	.016
SB	1.2147+-	.1003	15.548+-	1.284	.715+-	.059
" BA	.0000+-	.0742	.000+-	. 950	.000+-	.044
LA	.1861+-	.1263	2.382+-	1.617	.110+-	.074
HG	. 11,50+~	.0632	1.472+-	.809	.068+-	.037
PB	8.2736+~	.4223	105.902+-	5.405	4.869+-	.250

SAMPLE ID: NEA-013 PARTICLE SIZE: T ANALYSIS ID: MM969

N.E. SIDE - UPPER STACK AREA EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 1291.+- 10. MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCE	ENT
AL	4.6959+-	.6219	60.108+-	7.961	4.656+-	.618
SI	16.0835+-	2.2585	205.868+-	28.909	15.946+-	2.243
F	.1410+-	.0326	1.805+-	.417	.140+-	.032
S	.9843+-	.1885	12.599+-	2,413	.976+-	.187
CL	.0240+-	.0319	.307+-	.409	.024+-	.032
K	.6454+-	.0758	8.261+-	. 971	.640+-	.075
CA	3.2778+-	.3692	41.955+-	4.725	3.250+-	.367
TI	.2956+-	.0175	3.784+-	.224	.293+-	.017
V	.0250+-	.0049	.320+-	.063	.025+-	.005
CR	.0287+-	.0032	.367+-	.041	.028+-	.003
MN	.0695+-	.0051	.890+-	.065	.069+-	.005
FE	5.0930+-	.2592	45.190+ <del>-</del>	3.318	5.050+-	.260
NI	.0200+-	.0028	. 256+-	.036	.020+-	.003
CU	.6209+-	.0332	7.948+-	. 425	.616+-	.033
ZN	.3002+-	.0170	3.843+-	.218	.298+-	.017
GA	.0034+-	.0051	.044+-	.065	.003+-	.005
AS	2.3654+-	.1422	30.277+-	1.820	2.345+-	.142
SE	.0064+-	.0032	.082+-	.041	.006+-	.003
BR	.0239+-	.0127	.306+-	.163	.024+-	.013
RB	-+0000+-	.0044	.000+-	.056	.000+-	.004
SR	.0294+-	.0038	.376+-	.049	.029+-	.004
Y	.0113+-	.0064	.145+-	.082	.011+-	.006
ZR	.0169+-	.0160	.216+-	.205	.017+-	.016
MO	.0224+-	.0112	. 287+-	.143	.022+~	.011
PD	.0000+-	.0107	.000+-	.137	.000+~	.011
AG	.0285+-	.0151	.365+-	.193	.028+~	.015
CD	.0358+~	-0179	.458+-	- 229	.035+~	.018
IN	.0410+-	.0232	.525+-	. 297	.041+-	.023
SN	.0416+-	.0276	.532+-	. 353	.041+-	.027
SB	.2317+-	.0653	2.966+-	.836	.230+-	.065
BA	.0000+-	.1062	.000+-	1.359	.000+-	.105
LA	.0000+~	.1911	.000+-	2.446	.000+~	.189
HG	.01,13+-	.0205	.145+-	.262	.011+-	.020
PB	1.4147+-	. 0745	18.108+-	. 954	1.403+-	.075

SAMPLE ID: NEA-014 PARTICLE SIZE: T ANALYSIS ID: MM958 GODFREY ROASTER

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 2054.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FI	_TER	PERCE	ENT
AL	.4220+-	. 1976	5.402+-	2.529	.263+~	.123
SI	8.4673+-	1.1897	108.382+-	15.229	5.277+-	.742
P	.1450+-	.0333	1.856+-	.426	.090+~	.021
S -	1.1977+-	. 2568	15.331+-	3.287	.746+-	. 160:
CL -	.0491+-	.0425	.628+-	.543	.031+~	.026
K ·	.4203+-	.0511	5.380+-	.654	.262+-	.032
CA ·	3.4302+-	.3862	43.907+-	4.944	2.138+-	.241
TI	.3293+-	.0191	4.215+-	.244	.205+-	.012
V	.0292+-	.0052	.374+-	.067	.018+-	.003
CR	.0400+-	.0036	.512+-	.046	.025+~	.002
MN	.0767+-	.0054	.982+-	.069	.048+~	.003
FE	9.2747+-	. 4694	118.716+-	6.008	5.780+-	.294
NI	.0682+-	.0053	.873+-	.068	.043+-	.003
CU	3.9512+-	.2014	50.575+-	2.578	2.462+-	.126
ZN	-6944+-	.0402	8.888+-	.515	. 433+-	.025
GA	.0000+-	.0081	.000+-	.104	-000+-	.005
AS .	50.1358+-	2.5334	641.738+-	32.428	31.243+-	1.586
SE	.7307+-	.0513	9.353+-	.657	. 455+-	.032
BR	.5172+-	.2474	6.620+-	3.167	.322+-	. 154
RB	.0000+-	.0671	-000+-	.859	-000+-	.042
SR	-0092+-	.0046	.118+-	.059	-+600.	.003
Υ .	-+0000+-	.0180	-000+-	.230	-000+-	.011
ZR	.0000+-	.0139	-+000+-	.178	-+000	.009
MO	.0589+-	.0105	.754+-	.134	.037+-	.007
PD	.0000+-	.0525	.000+-	.672	.000+-	.033
AG	.0000+-	.0281	.000+-	.360	.000+-	.018
CD ·	.0589+-	.0189	. 754+-	.242	.037+-	.012
IN	-0000+-	.0194	-000+-	.248	-+000+-	.012
SN	.0000+-	.0266	.000+-	.340	.000+-	.017
SB	3.1172+-	.2085	39.900+-	2.669	1.943+-	.130
BA	.1785+-	.0872	2.285+-	1.116	.111+-	. 054
LA	-2794+-	. 1568	3.576+-	2.007	. 174+-	.098
HG	2.8141+-	.9191	36.020+-	11.764	1.754+-	. 573
PB	2.1775+-	1131	27.872+-	1.448	1.357+-	.071

SAMPLE ID: NEA-015 PARTICLE SIZE: T ANALYSIS ID: MM959

FLOOR OF ARSENIC KITCHEN

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 5735.+- 10. MICROGRAMS

ELEMEN	IT UG/C	M2	UG/FIL	UG/FILTER		ENT
AL	1.9319+-	.5895	24.728+-	7.546	.431+-	.132
SI	22.7655+-	3.1966	291.398+-	40.917	5.081+-	.714
P	.3960+-	.0897	5.068+-	1.148	.088+-	.020
s	.0000+-	1.5030	-+000+-	19.239	.000+-	.335
CL	-+0000+-	.2505	.000+~	3.206	-+000+-	.056
K	1.4376+-	.1673	18.401+-	2.141	.321+-	.037
CA	8.4405+-	.9475	108.039+-	12.128	1.884+-	.212
TI	.7188+-	.0476	9.201+-	. 609	.160+-	.011
V	.0757+-	.0148	.969+-	.189	.017+-	.003
CR	.1606+-	.0100	2.056+-	.128	.036+-	.002
MN	.2613+-	.0148	3.345+-	.189	.058+-	.003
FE	37.9310+-	1.9099	485.517+-	24.447	8.466+-	.427
NI	.2386+-	.0141	3.054+-	.180	.053+-	.003
CN	16.3822+-	.8293	209.692+-	10.615	3.656+-	. 185
ZN	3.2990+-	.1807	42.227+-	2.313	.736+-	.040
GA	-0000+-	.0462	-000+-	.591	.000+-	.010
AS	122.8012+~	6.2459	1571.855+-	79.948	27.408+-	1.395
SE	.2474+-	.0472	3.167+-	.604	.055+-	.011
BR	-+0000+-	.5285	-000+-	6.765	.000+-	.118
RB	-+0000+-	.1437	.000+-	1.839	-+000+-	.032
SR	.0000+-	.1042	-000+-	1.334	-000+-	.023
Y	-0000+-	.0596	.000+-	.763	.000+-	.013
ZR	.0436+-	.0287	<u>.</u> 558+-	.367	.010+-	.006
MO	.2039+-	.0234	2.610+-	.300	.046+-	.005
PD	.0000+-	2785	.000+-	3.565		.062
- AG	-+0000+-	.1091	.000+-	1.396	.000+-	.024
CD	.3646+-	.0717	4.667+-	.918	.081+-	.016
IN	-0000+-	.0302	.000+-	.387	-+000+-	.007
SN	.4204+-	.0584	5.381+-	.748	.094+-	.013
SB	7.8065+-	.5466	99.923+-	6.996	1.742+-	.122
BA	.0000+-	.1077	.000+-	1.379	.000+-	.024
LA	.0000+-	. 1796	.000+-	2.299	.000+-	.040
HG	1.41,63+-	.8139	18.129+-	10.418	.316+-	.182
PB	14.7906+-	্. 7530	189.320+-	9.638	3.301+-	.168

SAMPLE ID: NEA-016
PARTICLE SIZE: T
ANALYSIS ID: MM966
N. SIDE OF GODFREY ROASTER
EXPOSED AREA: 12.80 SQUARE CM
MASS OF DEPOSIT: 3207.+- 10. MICROGRAMS

ELEMENT	. ne/c	M2	UG/FIL	_TER	PERCE	ENT
AL	7.2473+-	.9697	92.765+-	12.412	2.893+-	.387
SI	27.1809+-	3.8160	347.916+~	48.845	10.849+-	1.523
F	.3010+-	.0684	3.853+-	.876	.120+-	.027
S.	2.8949+-	. 4353	37.055+-		1.155+-	.174
CL _	.0000+-	.1114	.000+-	1.426	.000+-	.044
K .	1.2241+-	.1412	15.669+-	1.807	. 489+-	.056
CA	7.1796+-	.8062	91.898+-	10.320	2.866+-	.322
TI	.6111+-	.0334	7.822+-	.428	. 244+-	.013
<b>V</b> _	.0435+-	.0080	.557+-	.102	.017+-	.003
CR	.0661+-	.0051	.846+~	. 065	.026+-	.002
MN .	.1520+-	.0092	1.946+-	.118	.061+-	.004
FE	12.9802+-	. 6557	166.147+-	8.393	5.181+-	.262
NI	.0824+-	.0061	1.055+-	.078	.033+-	.002
CU	3.6522+-	.1863	46.748+-	2.385	1.458+-	.074
- ZN	1.0803+-	.0581	13.828+-	.744	.431+-	.023
GA	.0000+-	.0098	.000+-	.125	.000+-	.004
AS	36.0397+-	1.8255	461.308+-	23.366	14.384+-	.730
SE	.2713+-	.0244	3.473+-	.312	108+-	.010
BR	.1515+-	.1670	1.939+-	2.138	.060+-	.067
RB	.0000+-	.0453	.000+-	.580	.000+-	.018
SR	.0602+-	.0047	.771+-	.060	.024+-	.002
Y	.0000+-	.0150	.000+-	.192	.000+-	.006
ZR	.0000+-	.0152	.000+-	. <b>.</b> 195	-+000	.006
MO	.0419+-	-0108	.536+-	.138	.017+-	.004
PD	.0000+-	.0330	.000+-	.422	.000+-	.013
AG	.0000+-	.0210	.000+-	.269	.000+-	.008
CD	.1178+-	.0206	1.508+-	.264	.047+-	.008
IN	.0000+-	.0213	.000+-	- 273	.000+-	.009
SN	.0000+-	.0269	°000+ <del>-</del>	.344	-000+-	.011
SB	1.3571+-	.2307	17.371+-	2.953	.542+-	.092
BA	.0000+-	.0938	.000+-	1.201	.000+-	.037
LA	.1437+-	.1626	1.839+-	2.081	.057+-	.065
HG	1.1323+-	.3231	14.493+-	4.136	. 452+-	.129
PB .	2.7784+-	.1436	35.564+-	1.838	1.109+-	.057

SAMPLE ID: NEA-017 PARTICLE SIZE: T ANALYSIS ID: MM967

CENTER OF GODFREY ROASTER

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 3253.+- 10. MICROGRAMS

ELEMEN	IT UG/C	M2	UG/FIL	UG/FILTER PER		ENT
AL	.8392+~	.3726	10.742+-	4.769	.330+-	.147
SI	15.3143+-	2.1506	196.024+-	27.528	6.026+-	.846
P	.1525+-	.0353	1.952+-	.451	.060+-	.014
S	1.3610+-	.2630	17.421+-	3.366	.536+~	.103
CL	.0000+-	.1261	.000+-	1.614	-000+-	.050
К	.8117+-	.0949	10.390+-	1.215	.319+-	.037
CA	4.5185+~	.5081	57.836+-	6.504	1.778÷-	.200
TI	.4195+~	.0238	5.370+-	.305	.165+-	.009
V	.0388+-	.0064	. 497+-	.082	.015+-	.00J
CR	.0614+-	.0049	.786+-	.063	.024+-	.002
MN	.1038+-	. 0069	1.329+-	.088	.041+-	.003
FE	11.1609+~	-5642	142.860+-	7.222	4.392+-	.222
NI	.1083+-	.0075	1.386+-	.096	.043+-	.003
CU	2.9715+-	.1519	38.035+-	1.944	1.169+-	.060
ZN	.6538+-	.0348	8.369+-	. 471	.257+-	.015
GA	.0000+~	.0089	.000+-	.114	.000+ <del>-</del>	.004
AS	105.7361+-	5.3372	1353.422+-	68.316	41.605+-	2.104
SE	.1324+-	.0270	1.695+-	.346	.052+-	.011
BR	.0000+-	.4466	.000+-	5.716	.000+-	.176
RB	.0000+-	.1213	.000+-	1.553	.000+-	.048
SR	.0268+~	.0057	.343+-	.073	.011+-	.002
Υ	.0000+-	.0306	.000+-	.392	.000+-	.012
ZR	.0000+-	.0185	.000+-	.237	.000+-	.007
MO	.0000+-	.0139	.000+-	.178	-000+-	.005
PD	-0000+-	.1942	-000+-	2.486	-000+-	.076
AG	.0000+-	.0755	.000+-	. 966	.000+-	.030
CD	.0982+-	.0248	1.257+-	.317	.039+-	.010
IN	-0000+-	.0258	.000+-	.330	-000+-	.010
SN	-+0000+-	.0334	.000+-	. 428	.000+-	.013
SB	3.9747+-	.2624	50.876+-	3.359	1.564+-	.103
BA	.0000+-	.1206	-000+-	1.544	-000+-	.047
LA	.0669+-	.2116	.856+-	2.708	.026+-	.083
HG	1.0049+-	.3837	12.863+-	4.911	.395+-	.151
PB	2.0116+-	1048	25.748+-	1.341	.792+-	.041

SAMPLE ID: NEA-018
PARTICLE SIZE: T
ANALYSIS ID: MN378
ENGINEERING WAREHOUSE
EXPOSED AREA: 12.80 SQUARE CM
MASS OF DEPOSIT: 1302.+- 10. MICROGRAMS

ELEMENT	ug/C	M2	UG/FIL	TER	PERCE	ENT
AL	4.2375+-	.5629	54.240+-	7.205	4.166+-	.554
SI	15.3862+-	2.1606	196.943+-	27.656	15.126+-	2.127
F	.1632+-	.0373	2.089+-	.478	.160+-	.037
S	.7540+-	.1939	9.652+-	2.483	.741+-	.191
CL	-+0530+-	.0349	. 422+-	. 447	.032+-	.034 -
K	.7053+-	.0825	9.028+-	1.056	.693+-	.081
CA	2.8744+-	.3240	36.792+-	4.147	2.826+-	.319
ΤI	.3747+-	.0214	4.796+-	. 274	.368+-	.021
V	.0420+-	.0060	. 538+-	. 077	.041+-	.006
CR	.0474+-	.0041	.607+-	. 052	047+-	.004
MN	.1013+-	-0066	1.297+-	.084	.100+-	.007
FE	6.8741+-	.3487	87.988+-	4.463	6.758+-	.347
NI	.0510+-	.0044	. 653+-	. 056	.050+-	.004
CU	2.1102+-	1.084	27.011+-	1.388	2.075+-	108
ZN	.5394+-	.0302	6.904+-	.387	.530+-	.030
GA	-+8800.	.0061	.106+-	.078	.008+~	.006
AS	10.6962+-	.5485	136.911+-	7.021	10.515+-	.545
SE	.1682+-	.0078	2.153+-	.125	.165+-	.010
BR	.0877+-	.0524	1.123+-	. 671	.086+-	.052
RB	.0000+~	.0143	.000+-	.183	.000+-	.014
SR	.0314+-	.0033	.402+-	.042	.031+-	.003
Y	.0000+-	.0075	.000+-	. 096	-+000+-	.007
ZR	.0000+-	.0132	.000+-	.169	.000+-	.013
MO	.0000+-	.0090	.000+-	.115	.000+-	.009
PD	.0000+-	.0111	.000+-	.142	.000+-	.011
AG	.0000+-	.0124	.000+-	. 159	.000+-	.012
CD	.0000+-	.0155	.000+-	.198	.000+-	.015
IN	.0277+-	.0179	.355+-	. 229	.027+-	.018
SN	.0466+-	.0233	.596+-	. 298	- 046+-	.023
SB	.9834+-	. 1034	12.588+-	1.324	.967+-	.102
BA	-+0000+-	.0888	.000+-	1.137	.000+-	.087
LA	.1759+-	.1545	2.252+-	1.978	.173+-	. 152
, HG	.5734+-	.1160	7.340+-	1.485	.564+-	.114
PB	1.7170+-	0897	21.978+-	1.148	1.688+-	.089

SAMPLE ID: NEA-019
PARTICLE SIZE: T
ANALYSIS ID: MM960
N. END OF COOLING POND
EXPOSED AREA: 12.80 SQUARE CM
MASS OF DEPOSIT: 4160.+- 10. MICROGRAMS

ELEMENT	r ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	21.5875+-	2.8497	276.320+-	36.477	6.642+-	.877
SI	52.6770+-	7.3943	674.266+-	94.646	16.208+-	2.275
F	4.5528+-	1.0192	58.275+-	13.046	1.401+-	.314
S	1.2664+-	.2265	16.210+-	2.899	.390+-	.070
CL	.0000+-	.2823	.000+-	3.614	-+000+-	.087
ĸ	2.7330+-	.3105	34.983+-	3.974	.841+-	.096
CA	14.0728+-	1.5784	180.132+-	20.203	4.330+-	. 486
ΤI	.9374+-	.0887	11.999+-	1.135	.288+-	.027
V	.0692+-	.0314	.886+-	.402	.021+-	.010
CR	.2344+-	.0140	3.000+-	. 179	.072+-	.004
MN	.1818+-	.0111	2.327+-	.142	.056+-	.003
FE	13.7258+-	.6932	175.690+-	8.873	4.223+-	.214
NI	.0701+-	.0054	.897+-	.069	.022+-	.002
CU	5.1083+-	.2599	65.386+-	3.327	1.572+-	.080
ZN	.2309+-	.0251	2.956+-	.321	.071+-	.008
GA	.0000+-	.0055	.000+-	.070	.000+-	.002
· AS	5.9608+-	.3116	76.298+-	3.988	1.834+-	.096
SE	.0825+-	.0085	1.056+-	.109	.025+-	.003
BR	.0825+-	.0313	1.056+-	.401	.025+-	.010
RB	.1014+-	.0087	1.298+-	.111	.031+-	.003
SR	.0000+-	.0077	.000+-	.09 <del>9</del>	.000+-	.002
Y	-+0000+-	.0064	-+000+-	.082	-+000+-	.002
ZR ·	.0000+-	.0160	-000+-	.205	.000+-	.005
MO	-+0000+-	.0088	-+000+-	.113	-+000+-	.003
PD	.0000+-	.0107	-+000+	.137	.000+-	.003
AG	.0000+-	.0161	.000+-	.206	-+000+-	.005
CD	-+0000+-	.0141	.000+-	.180	.000+-	.004
IN	-+0000+-	.0190	.000+-	.243	.000+-	.006
SN	.1444+-	.0242	1.848+-	.310	.044+-	.007
SB	. 4377+-	.0693	5.603+-	.887	. 135+-	.021
BA	2.3334+-	.2537	29.868+-	3.247	.718+-	.078
LA	.2032+-	. 1557	2.601+-	1.993	.063+-	.048
HG	.3213+-	.0847	4.113+-	1.084	.099+-	.026
PB	1.4489+-	0761	18.546+-	. 974	. 446+-	.023

#### 199/20-005 PROTOCOL:

SAMPLE ID: NEA-020 PARTICLE SIZE: T ANALYSIS ID: MM961

COOLING POND

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 3400.+- 10. MICROGRAMS

ELEMEN	IT UG/C	UG/CM2		TER	PERCE	ENT
AL	21.6514+-	2.8578	277.138+-	36.579	8.151+-	1.076
SI	26.3563+-	3.7005	337.361+-	47.366	9.922+~	1.393
P	4.8708+-	1.0903	62.346+-	13.956	1.834+-	.411
S	. 8865+-	.1715	11.347+-	2.195	.334+-	.065
CL	-0000+-	.2142	.000+-	2.742	.000+-	.081
K -	1.9206+-	.2196	24.584+-	2.811	.723+-	.083
CA -	13.8689+-	1.5555	177.522+-	19.910	5.221+-	.586
TI	-4660+-	.0498	5.965+-	.637	.175+-	.019
٧ .	.0459+-	.0184	.588+-	.236	.017+~	.007
CR	.2136+-	.0126	2.734+-	. 161	OBO+-	.005
MN ·	.1285+-	.0085	1.645+-	.109	.048+-	.003
FE	7.4070+-	.3755	94.B10+-	4.806	2.789+~	.142
NI	-0630+-	.0050	-+608.	.064	.024+-	.002
CN	6.2932+-	.3197	80.553+-	4.092	2.369+-	.121
. ZN	.1241+-	.0273	1.588+-	.349	.047+-	.010
GΑ	.0000+-	.0046	.000+-	.059	.000+-	
AS	1.3019+-	.0918	16.664+-	1.175	.490+-	.035
SE	.0503+-	.0053	.644+-	.068	.019+-	.002
BR	.0178+-	.0077	.228+-	.099	.007+-	.003
RB	.0000+-	.0031	-000+-	.040	.000+~	.001
SR	.1221+-	.0077	1.563+-	.099	.046+-	.003
Y	.0000+-	.0053	. 000+-	.068	.000+~	.002
ZR	.0000+-	.0156	-000+-	.200	.000+-	.006
MO	.0000+-	.0088	.000+-	.113	.000+-	.003
PD	.0107+-	.0089	.137+-	.114	.004+-	.003
AG	.1290+-	.0169	1.651+-	.216	.049+-	.006
CD	.0050+-	.0124	.064+-	. 159	.002+-	.005
· IN	.0000+-	.0161	-+000+-	.206	.000+-	.006
SN	.0444+-	.0222	.568+-	. 284	.017+-	.008
SB -	.1184+-	.0518	1.516+-	. 663	.045+-	.020
BA	1.3412+-	. 1520	17.167+-	1.946	.505+-	.057
LA	.1129+-	.1489	1.445+-	1.906	.043+-	.056
HG	.0305+-	.0168	.390+-	.215	.011+-	.006
PB	1.1757+-	.0623	15.049+-	.797	. 443+-	.023

# 199/20-006 PROTOCOL:

SAMPLE ID: NEA-021 PARTICLE SIZE: T ANALYSIS ID: MM968

PARKING LOT - N. OF ADMINISTRATION BUILDING EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 1090.+- 10. MICROGRAMS

ELEMEN	T UG/C	M2	UG/FILTER		PERCE	ENT
AL	5.3086+-	.7026	67.950+-	8.993	6.234+-	.827
SI	16.0424+-	2.2527	205.343+-	28.835	18.839+-	2.651
۴	.5538+-	.1244	7.089+~	1.592	.650+-	.145
S	.6145+-	.1355	7.866+-	1.734	.722+-	- 159
CL	.0366+-	.0265	.468+-	.339	.043+-	.031
ĸ	.6881+-	.0804	8.808+-	1.029	-+808+-	.095
CA	2.2075+-	.2493	28.256+-	3.191	2.592+-	. 294
ΤI	.4126+-	.0234	5.281+-	.300	.485+-	.028
V	.0496+-	.0066	.635+-	.084	.058+-	.008
CR	.0530+-	.0044	.678+-	.056	.062+-	.005
MM	-0888+-	.0061	1.137+-	.078	.104+-	.007
FE	5.1052+-	. 2598	65.347+ <del>-</del>	3.325	5.995+-	.310
NI	-0469+-	.0042	.600+-	.054	.055+-	.005
CU	1.9492+-	.1003	24.950+-	1.284	2.287+-	.120
ZN	.1628+-	.0130	2.084+-	.165	.191+-	.015
GA	.0071+-	.0042	.091+-	.054	.008+-	.005
AS	1.5873+-	.0998	20.317+-	1.277	1.864+-	.118
SE	-+0000+-	.0027	-+000+-	.035	.000+-	.003
BR	.0200+-	.0091	.256+-	.116	.023+-	.011
RB	-+0000+-	.0035	.000+-	.045	.000+-	.004
SR	.0364+-	.0037	. 466+-	.047	.043+-	.004
Y	.0086+-	.0053	.110+-	.068	.010+-	.006
ZR	.0262+-	.0146	.335+-	.187	.031+-	.017
MO	.0208+-	.0104	.266+-	.133	.024+-	.012
PD	.0238+-	.0119	.305+-	.152	.028+-	.014
AG	.0302+-	.0151	.387+-	.193	.035+-	.018
CD	.0160+-	.0152	.205+-	.195	.019+-	.018
IN	.0244+-	.0205	.312+-	.262	.029+-	.024
SN	.0062+-	.0239	.079+-	.306	.007+-	.028
SB	.2405+-	.0606	3.078+-	.776	.282+~	.071
BA	.0000+-	.1050	.000+-	1.344	.000+-	.123
LA	.1550+-	.1787	1.984+-	2.287	.182+-	.210
HG	.0296+-	.0148	.379+-	.189	.035+-	.017
PB	1.0809+-	.0576	13.836+-	.737	1.269+-	.069

SAMPLE ID: NEA-022 PARTICLE SIZE: T ANALYSIS ID: MM962

ROADWAY N. OF POWER HOUSE

EXPOSED AREA: 12.80 SQUARE CM

MASS OF DEPOSIT: 599.+- 10. MICROGRAMS

ELEMENT	UG/C1	12	UG/FIL	TER	PERCE	ENT
AL	1.1166+-	.1498	14.292+-	1.917	2.386+-	.323
SI	4.1156+-	.5789	52.679+-	7.410	8.795+-	1.246
Ė.	.1535+-	.0356	1.965+-	. 455	.328+-	.076
S	.5122+-	.0790	6.557+-	1.012	1.095+-	.170
CL	.0000+-	.1125	.000+-	1.440	-+000+-	.240
ĸ	.1839+-	.0265	2.353+-	.339	.393+-	.057
CA	6.4761+-	.7273	82.894+-	9.310	13.839+-	1.571
TI	.0902+-	.0048	1.155+-	.087	.193+-	015
V	.0098+-	.0024	.125+-	.031	.021+-	.005
CR	.0251+-	.0026	.321+-	.033	.054+-	.006
MN	.0332+-	.0031	.425+-	.040	.071+-	.007
FE	2.3851+-	.1231	30.529+-	1.576	5.097+-	.276
NI	0177+-	.0024	.227+-	.031	-038+-	.005
CU	1.1767+-	.0612	15.062+-	.783	2.514+-	. 137
ZN	.1010+-	.0085	1.293+-	.109	.216+-	.019
GA	.0000+-	.0020	.000+-	.026	-+000+-	.004
AS	.7150+-	.0415	9.152+-	.531	1.528+-	.092
SE	.0012+-	-0017	.015+-	.022	-+200.	.004
BR	-+0000+-	.0045	.000+-	.058	000+-	.010
R:B	.0000+-	.0021	.000+-	.027	.000+-	.004
SR	.0148+-	.0024	.189+-	.031	.032+-	.005
Y	.0053+-	.0029	.068+-	.037	.011+-	-006
ZR	-+0000+-	.0103	.000+ <del>-</del>	.132	.000+-	.022
MO	.0000+-	.0073	.000+-	.093	.000+-	.016
PD	.0041+-	.0073	.052+-	.093	.009+-	.016
AG	.0114+-	.0095	.146+-	.122	.024+~	.020
CD	.0232+-	.0116	<b>.</b> 297+-	.148	.050+-	.025
IN	-+0000+-	.0135	.000+-	<b>.</b> 173	-+000	.029
SN	.0194+-	.0176	. 248+ <del>-</del>	. 225	.041+-	.038
SB	.6487+-	.0742	8.303+-	. 950	1.386+-	.160
BA	.0734+-	.0702	.940+-	. 877	.157+-	. 150
LA	.0304+~	.1253	.389+~	1.604	.065+-	.268
HG	-+0000-	.0049	.000+-	.063	.000+-	.010
PB	.3252+-	.0193	4.163+-	.247	. 695+-	.043

#### 199/20-001 PROTOCOL: 3

SAMPLE ID: NEA-001
PARTICLE SIZE: F = (FINE = 0-2.5 MICRONS)

ANALYSIS ID: MM929

STORAGE TANK

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 114.+- 10. MICROGRAMS

		1					TAL	John
ELEMENT	ug/c	M2 X NOA	_ UG/FIL	TER	PERCE	ENT ) SE	701,000	15
		•	_	~ / ·				
AL	1.7489+-	.2331	3.760+-	.50	3.298+-	.526		
SI	4.3476+-	.6411	9.347+-	1.378	8.199+-	1.407	,	_
P	.1142+-	.0263	.245+-	.057	.215+-	.053	$\omega$	E
S	1.3010+-	.2193	2.797+-	472	2.454+-	.466		
CL	.0120+-	.0321	.026+-	.069	.023+-	.061	T	$\mathfrak{D}$
K	.2159+-	.0277	. 464+-	. 059	.407+-	.043	•	
CA	1.4675+-	.1663	3.155+~	.358	2.768+-	.397		•
TI	.1367+-	.0093	. 294+-	.020	.258+-	.029		
V	.0199+-	.0034	.043+-	.007	.038+-	.007		
CR	.0442+-	.0038	.095+-	.008	-+280.	.010		
MN	.0526+-	.0042	.113+-	.009	.099+-	.012		
FE '	6.5646+-	.3332	14.114+-	.716	12.381+-	1.255		
NI	.0308+-	.0033	.066+-	.007	.058+-	.008		
CU	3.3151+-	.1693	7.127+-	. 364	6.252+-	.635		
ZN	-7139+-	.0401	1.535+-	.086	1.346+-	.140		
GA	.0000+-	.0059	.000+-	.013	.000+-	.011	,	
AS	1.9280+-	.1299	4.145+-	. 279	3.636+-	.402		
SE	-+0000+-	.0023	-+000+-	.005	-+000+-	.004		
BR	0000+-	.0099	.000+-	.021	-+000+-	.019		
RB	.0000+-	.0035	-+000+-	.008	-000+-	.007		
SR	.0045+-	.0027	-010+-	.006	-+800.	.005		
Υ .	.0042+-	.0064	.009+	.014	.008+-	.012		
ZR	.0000+-	.0133	-000+-	.029	.000+~	.025		•
MO	.0096+-	.0090	.021+-	.019	.018+-	.017		
PD	.0160+-	.0102	.034+-	.022	-+050+-	.019	-	
AG	.0105+-	.0119	.023+-	.026	.020+-	.023		
CD	.0541+-	.0155	.116+-	.033	.102+-	.031		•
IN	.0287+-	.0190	-062+-	.041	.054+~	.036		
⊊SN	.0576+-	.0238	.124+-	.051	.109+-	.046		
SB	-2265+-	.0557	.487+-	.120	. 427+-	.112		V
BA	-+0000+-	.0863	.000+-	. 186	.000+-	.163		- '
LA		.1560	.000+-	.335	.000+-	. 294		
HG	.0182+-	.0091	.039+-	.020	.034+-	.017	!	
PB	1.5913+-	0834	3.421+-	. 179	3.001+-	.307	٠.	•
		~			1			

SAMPLE ID: NEA-002 PARTICLE SIZE: F ANALYSIS ID: MM933

PLATE TREATER

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 188.+- 10. MICROGRAMS

ELEMENT	n <u>e\c</u>	UG/CM2		UG/FILTER		PERCENT	
AL	1.6900+-	.2259	3,634+-	. 486	1.933+-	. 278	
SI	4.8879+-	.7207	10.509+-	1.549	5.590+-	.876	
F	.2817+-	.0636	.606+-	.137	.322+-	.075	
<b>S</b> .	2.0433+-	.9030	4.393+-	1.942	2.337+-	1.040	
CL	-+0000+-	.1502	.000+-	.323	.000+-	.172	
ĸ	.3567+-	.0439	.767+-	.094	.408+-	.055	
CA	2.7424+-	.3092	5.896+-	. 665	3.136+-	.391	
TI	.2026+-	.0127	.436+-	.027	.232+-	.019	
V	.0256+-	.0041	.055+-	.009	.029+-	.005	
CR	.0693+-	.0051	. 149+-	.011	.079+-	.007	
MN	.0724+-	.0052	.156+-	.011	.083+-	.007	
FE	10.3070+-	.5213	22.160+-	1.121	11.787+-	.865	
NI	.0778+-	.0058	.167+-	.012	089+-	.008	
CU	6.6969+-	.3401	14.396+-	.731	7.659+-	.563	
ZN	.5088+-	.0389	1.094+-	.084	.582+-	.054	
GA	.0000+-	.0295	.000+-	.043	-000+-	.034	
AS	6.0909+-	.5881	13.095+-	1.264	6.966+-	.768	
SE	-+0000+-	.0067	.000+-	.014	.000+-	.008	
BR	.0000+-	.0278	.000+-	.060	.000+-	.032	
R:B	.0000+-	.0085	.000+-	.018	.000+-	-010	
SR	.0051+-	.0036	.011+-	.008	.006+-	.004	
Y	.0414+-	.0313	.089+-	.067	.047+-	.036	
ŽR	.0000+-	.0201	.000+-	.043	.000+-	.023	
MO	.0120+-	.0082	.026+-	.018	.014+-	- 009	
₽D	-0000+-	.0119	.000+-	.026	.000+-	.014	
AG	.0000+-	.0131	.000+-	- 028	.000+-	.015	
CD	.0776+-	.0184	. 167+-	.040	.089+-	.022	
IN	.0000+-	.0180	.000+-	.039	.000+-	.021	
SN	.1944+-	.0322	.418+~	.069	.222+-	.039	
SB	.6713+-	.0909	1.443+-	.195	.768+-	.112	
BA	.0000+-	.0792	-000+-	.170	.000+-	.091	
LA	.0000+-	. 1377	.000+-	. 296	.000+-	.157	
HG	.0364+-	.0182	.078+~	. 039	.042+~	.021	
PB	9.5076+-	4850	20.441+-	1.043	10.873+-	.801	

SAMPLE ID: NEA-003 PARTICLE SIZE: F ANALYSIS ID: MM909 REVERB FURNACE

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 116.+- 10. MICROGRAMS

ELEMENT	UG/C	M2	UG/FILT	ER	PERCE	ENT
AL	.9044+-	.1223	1.944+-	. 263	1.676+-	.269
SI	2.5044+-	.3697	5.384+-	.795	4.642+-	.793
Þ	.1808+-	.0410	.389+-	.088	.335+-	.081
S	1.9819+-	.3231	4.261+-	.695	3.673+-	.677
CL	.0000+-	.0630	.000+-	.136	-000+-	.117
ĸ	.2970+-	.0367	.639+-	.079	.550+-	.083
CA	.8180+-	.0936	1.759+-	.201	1.516+-	.217
TI	.1123+-	.0080	.241+-	.017	.208+-	.023
V	.0207+-	.0032	.045+-	.007	-+880.	.007
CR	.0480+-	.0040	.103+-	.009	.089+-	.011
MN	.0517+-	.0041	.111+-	.009	.096+-	.011
FE	6.8054+-	.3453	14.632+-	.742	12.613+-	1.262
NI	.0412+-	.0038	.089+-	.008	.076+-	.010
CU	4.8873+-	.2487	10.508+-	.535	9.058+-	• 907
ZN	.3958+-	.0297	.851+-	.064	.734+-	.084
GA	-+0000+-	.0082	-+000+-	.018	+000+-	.015
AS	5.3821+-	.3007	11.572+-	.647	9.975+-	1.025
SE	.0023+-	.0037	.005+-	.008	.004+-	.007
BR	-+0000+-	.0243	.000+-	.052	.000+-	.045
RB	-+0000+-	.0068	.000+-	.015	.000+-	.013
SR	.0057+-	.0025	.012+-	.005	.011+-	.005
Y	-+0000+-	.0088	.000+-	.019	.000+-	.016
ZR	-0000+-	.0122	.000+-	.026	.000+-	.023
MO	-+0000+-	-0086	.000+-	.018		.016
PD	.0000+-	.0106	.000+-	.023	.000+-	.020
AG	-0000+-	.0130	-000+-	.028	.000+-	.024
CD	-+0000+-	.0143	.000+-	.031	.000+-	.027
IN	.0263+-	.0166	.057+-	.034	• 049+-	.031
SN	.0927+-	.0227	.199+-	.049	. 172+-	.045
SB	-6884+-	.0785	1.480+-	169	1.276+-	.182
ВА	.1334+-	.0798	. 287+-	-172	.247+-	.149
LA	.0076+-	.1383	.016+-	. 297	.014+-	. 256
HG	.0045+-	.0148	.010+-	.032	-+800.	.027
PB	2.3921+-	.1239	5.143+-	. 266	4.434+-	.446

SAMPLE ID: NEA-004 PARTICLE SIZE: F ANALYSIS ID: MM913 N.W. REFINERY #1

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 334.+- 10. MICROGRAMS

ELEMEN	T UG/C	M2	UG/FIL	TER	PERCE	PERCENT	
AL	3.6589+-	. 4857	7.867+-	1.044	2.355+-	.321	
SI	9.0532+-	1.3341	19.464+-	2.868	5.828+-	.875	
P	.2799+-	.0707	.602+-	. 152	.180+-	.046	
S	5.7929+-	.6990	12.455+-	1.503	3.729+-	.464	
CL	.0000+-	.4439	.000+-	<b>.</b> 954	.000+-	. 286	
K	.3729+-	.0633	.802+-	.136	.240+-	.041	
CA	29.1647+-	3.2687	62.704+-	7.028	18.774+-	2.178	
TI	.3049+-	.0179	.656+-	.038	.196+-	.013	
V	.0211+-	.0048	.045+-	.010	.014+-	.003	
CR	.0371+-	.0035	.080+-	-008	.024+-	.002	
MN	.0628+-	.0047	. 135+-	.010	· 040+-	.003	
FE	5.9657+-	.3031	12.826+-	.652	3.840+-	.226	
NI	.2022+-	.0123	. 435+-	. 026	.130+-	.009	
CN	4.4388+-	.2260	9.543+-	. 486	2.857+-	. 169	
ZN	.5300+-	.0339	1.140+-	. 073	.341+-	.024	
GA	-+0000+-	.0082	.000+-	.018	.000+-	.005	
AS	4.9168+-	.2802	10.571+-	.602	3.165+-	.204	
SE	.0070+-	.0035	.015+-	.008	.005+-	.002	
BR	.0198+	.0237	.043+-	.051	.013+-	.015	
RB	-+0000+-	.0069	.000+-	.015	.000+-	.004	
SR	.0416+-	.0039	.089+-	.008	.027+-	.003	
Υ	-+0000+-	.0090	-000+-	.019	.000+-	.006	
ZŔ	.0157+-	.0144	.034+~	.031	.010+-	.009	
MO	.0171+-	.0095	.037+-	.020	.011+-	.006	
PD	.0210+-	.0108	.045+-	.023	.014+-	.007	
AG	.0620+-	.0181	.133+-	.039	.040+-	.012	
CD	.1134+-	.0186	.244+-	.040	.073+-	.012	
IN	-0300+-	.0198	.065+-	.043	.019+-	.013	
SN	.0551+-	.0277	.118+-	.060	-+25	.018	
SB	1.4583+-	.1319	3.135+-	. 284	<b>.</b> 939+ <del>-</del>	. 089	
BA	1900+-	.0950	. 409+	. 204	.122+-	.061	
LA	-0000+-	.1643	.000+-	.353	.000+-	.106	
HG	.0043+-	.0114	.009+-	.025	.003+-	.007	
PB	2.4172+-	1252	5.197+-	. 269	1.556+-	.093	

SAMPLE ID: NEA-005 PARTICLE SIZE: F ANALYSIS ID: MM941 REFINERY #3 - S. END

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 216.+- 10. MICROGRAMS

ELEMENT UG/CM2		M2	UG/FILTER		PERCENT	
AL	5.7951+	.7676	12.460+-	1.650	5.768+-	.809
SI	11.5551+-	1.7025	24.843+-	3.660	11.502+-	1.776
P	.4006+-	.0904	.861+-	.194	.399+-	.092
S	1.8645+-	.2681	4.009+-	.576	1.856+-	.280
CL	.0000+-	.1986	-+000+-	. 427	.000+-	.198
ĸ	.5611+-	.0668	1.206+-	. 144	.559+-	.071
CA	5.6034+-	. 6296	12.047+-	1.354	5.577+-	.678
ΤI	.4133+-	.0234	.889+-	.050	.411+-	.030
V	.0350+-	.0041	.075+-	.013	.035+-	.006
CR	.0852+-	.0060	.183+-	.013	.085+-	.007
MN ·	.0861+-	.0060	.185+-	.013	.086+~	.007
FE	6.8992+-	.3500	14.833+-	.752	6.867+-	.472
NI	.3367+-	-0191	.724+-	.041	.335+~	.025
CU	4.6360+-	.2360	9.967+-	.507	4.615+-	.318
ZN	.3042+-	.0258	.654+-	.055	.303+~	.029
GA	.0095+-	.0057	.020+-	.012	.009+-	.004
AS	2.7236+-	.1626	5.856+-	.350	2.711+~	.205
SE	.0166+-	.0033	.036+-	.007	.017+-	.003
BR	.0000+-	.0127	-+000	.027	.000+~	.013
RB .	-+0000+-	.0039	-000+-	.008	.000÷~	.004
SR	.0144+-	.0027	.031+-	.006	.014+-	.003
. <b>Y</b>	-0083+-	.0043	.018+-	.014	-+800.	.006
ZF:	.0000+-	.0135	-+000	.029	.000+-	.013
MO	-+0000+-	.0078	-+000+-	.017	-+000+-	.008
PD	.0123+-	.0091	.026+-	.020	.012+~	.009
AG	.0309+-	.0148	.066+-	.032	.031+-	.015
CD	.0231+-	.0130	.050+-	.028	.023+-	.013
IN	.0123+-	.0167	.026+-	.036	.012+-	.017
SN	.0422+-	.0209	091+-	.045	.042+-	.021
SB	.6445+-	.0766	1.386+-	. 165	.642+-	.082
BA	.0000+-	.0775	.000+-	. 167	.000+-	.077
LA	-+0000+-	.1352	-+000+-	.291	.000+-	. 135
HG	.0176+-	.0088	.038+-	.019	.018+-	.009
PB	1.5958+-	0836	3.431+-	.180	1.588+-	.111

SAMPLE ID: NEA-006
PARTICLE SIZE: F
ANALYSIS ID: MM943
HERSHEKOFF ROASTERS
EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 580.+- 10. MICROGRAMS

ELEMEN	IENT UG/CM2		UG/FILTER		PERCENT :	
AL	4.7695++	.6339	10.255+~	1.363	1.768+-	. 237
SI	10.7044+-	1.5774	23.015+~	3.391	3.968+-	.589
ь 27	.7041+-	.1603	1.514+-	.345	.261+-	.060
່ຣ	7.3837+-	1.2926	15.875+-	2.779	2.737+-	.481
CL -	.1190+-	.1707	.256+~	.367	.044+-	.063
K	.9816+-	.1707	2.110+-	. 255	.364+-	.044
CA	22.2106+-	2.4899	47.753+-	5.353	8.233+-	.934
TI	.7558+-	.0407	1.625+-	.088	.280+-	.016
V	.1231+-	.0117	.265+~	.025	.046+-	.004
CR -	.2913+-	.0145	.626+-	.035	.108+-	.004
MN	.3790+~	.0209	.815+~	.035	.140+-	
FE ·	58.4779+-	2.9427	125.727+-	6.327	21.677+-	1.153
NI -	.2204+-	.0132	.474+-	.028	.082+-	.005
				1.113		
CU .	10.2100+-	-5176	21.952+-	.136	3.785+-	.203
ZN	.9104+-	.0634	1.957+~		.337+-	.024
GA	.0419+-	.0295	.090+-	.063	.016+-	.011
AS	11.7269+-	.7754	25.213+-	1.667	4.347+-	. 297
SE	.0166+-	.0083	.036+-	.018	.006+-	.003
BR	.0000+-	.0514	.000+-	.111	.000+-	.019
RB	.0000+-	.0145	-000+-	.031	.000+-	.005
SR	.0203+-	.0051	.044+-	.011	.008+-	.002
Y	.0453+-	.0314	- 097+-	.068	.017+-	.012
ZR	-0424+-	.0212	-091+-	.046	.016+-	008
MO	<u>.</u> 0904+ <del>-</del>	.0117	.194+-	.025	.034+-	.004
PD	.0000+-	-0168	.000+-	. 036	-000+-	.006
AG	.0692+-	.0189	.149+-	.041	-026+-	.007
CD	.0000+-	.0217	.000+-	.047	.000+-	.008
. IN	.0000+-		.000+-	.044	-000+-	.008
SN	. 1456+-	.0353	.313+-	.076	. 054+-	.013
SB	1.7417+-	1182	3.745+-	. 254	.646+-	.045
BA	.1301+-	.0877	.280+-	. 189	.048+-	. 033
LA	.0000+-	. 1513	.000+-	.325	- 000+-	.056
HG	.0000+-	.0333	.000+-	.072	.000+-	.012
PB	9.4898+-	4841	20.403+-	1.041	3.518+-	. 189

#### 199/20-001 PROTOCOL: SA

SAMPLE ID: NEA-007 PARTICLE SIZE: F ANALYSIS ID: MM915 S. REFINERY #1

EXPOSED AREA:

2.15 SQUARE CM

MASS OF DEPOSIT: 113.+- 10. MICROGRAMS

ELEMENT	UG/CM2		UG/FIL1	UG/FILTER		PERCENT	
AL	.9594+-	.1291	2.063+-	.277	1.825+-	. 274	
SI	2.9733+-	.4387	4.393+~	.943	5.657+-	. 973	
۴	.1589+-	.0363	.342+-	.078	.302+-	.074	
S	1.0946+-	.1980	2.353+-	.426	2.083+-	.419	
CL	.0000+-	.1332	.000+-	.286	.000+-	. 253	
K	.1958+-	.0257	.421+-	.055	.373+-	.059	
CA	2.4418+-	. 2755	5.250+-	.592	4.646+-	-666	
TI	.1354+-	.0092	.291+-	.020	.258+-	.029	
V	.0215+-	.0034	.046+~	.007	.041+-	.007	
CR	.0374+-	.0035	.080+~	.008	.071+-	.009	
MN	.0458+-	.0039	.098+-	.008	.087+-	.011	
FE	5.7435+-	.2919	12.349+-	.629	10.928+-	1.115	
NI	.1130+-	.0077	.243+-	.017	.215+-	.024	
cu	3.7987+-	.1937	8.167+-	.416	7.228+-	.738	
ZN	.3176+-	.0238	. 683+~	.051	.604+-	.070	
GA	.0040+-	.0055	.009+-	.012	.008+-	.010	
AS	3.2671+-	.1842	7.024+~	.396	6.216+-	.652	
SE	.0148+-	.0036	.032+~	.008	.028+-	.007	
BR	-0083+-	.0158	.018+-	.034	.016+-	.030	
RB	.0000+-	.0048	.000+-	.010	-000+-	.009	
SR	.0068+-	.0026	.015+~	.006	.013+-	.005	
Υ	.0000+-	.0062	.000+-	.013	.000+-	.012	
ZR	.0000+-	.0126	.000+-	.027	.000+-	.024	
MO	.0123+-	.0086	.026+-	.018	.023+-	.016	
מפ	.0000+-	.0101	.000+-	.022	.000+-	.020	
AG	<b>.</b> 1440+-	.0179	.310+-	.038	. 274+-		
CD	.0577+ <del>-</del>	.0151	.124+-	.032	.110+-	.030	
IN	.0358+-	.0183	• 077+ <del>-</del>	.039	.068+-	.035	
SN	.0000+-	.0225	.000+ <del>-</del>	.048	-000+-	.043	
SB	.7020+-	.0812	1.509+-	.175	1.336+-	.195	
BA	.0129+-	.0833	.028+-	.179	.025+-	.159	
LA	.0000+-	.1497	.000+-	.322	.000+-	.285	
HG	-+0000+-	.0073	.000+-	.016	.000+-	.014	
PB	1.4996+-	0787	3.224+-	.169	2.853+-	.294	

SAMPLE ID: NEA-008 PARTICLE SIZE: F ANALYSIS ID: MM945 CENTRAL CHANGE HOUSE

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 205.+- 10. MICROGRAMS

ELEMENT	UG/C	M2	UG/FIL	TER	PERCENT	
AL	3.6745+-	. 4877	7.900+-	1.048	3.854+-	.545
SI	B.7719+-	1.2926	18.860+-	2.779	9.200+-	1.428
P	.4430+-	.0998	.952+-	.214	. 465+-	.107
S	1.9984+-	.3378	4.297+-	.726	2.096+-	.369
CL	.0000+	.1824	.000+-	.392	.000+-	.191
ĸ	.4923+-	.0588	1,058+-	.126	.516+-	.067
CA	3.8852+-	.4372	8.353+-	.940	4.075+-	.500
TI	.3438+-	.0199	.739+-	.043	.361+-	.027
V	.0386+-	.0056	.083+-	.012	.040+-	.006
CR	.1386+-	.0086	.298+-	.018	. 1.45+~	.011
MN	.0995+-	.0068	.214+-	.015	.104+-	.009
FE	9.4945+-	. 4805	20.413+-	1.033	9.958+-	.700
NI	.1677+-	.0105	.361+-	.023	.176+-	.014
CU	9.6748+-	4905	20.801+-	1.055	10.147+-	.714
ZN	.4869+-	.0476	1.047+~	.102	.511+~	.056
GA	.0176+-	.0088	.038+-	.019	.018+~	.009
AS	5.3333+ <del>-</del> .	.3025	11.467+-	.650	5.593+-	.418
SE	.0504+-	.0047	.108+-	.010	.053+-	.006
BR	.0000+-	.0237	.000+-	.051	.000+-	.025
RB	-0000+-	- 0067	.000+-	.014	-000+-	.007
SR	-0157+-	.0027	.034+-	.006	.016+-	.003
Υ	.0152+-	.0092	-+5550.	.020	.016+-	.010
ZR	-0000+-	.0129	.000+-	.028	.000+-	.014
MO	.0171+-	.0077	.037+-	-017	.018+-	.00B
PD	.0130+-	.0086	.028+-	.018	.014+-	.009
AG	.0436+-	.0136	.094+-	.029	.046+-	.014
CD	.0272+-	-0136	.058+-	.029	.029+~	.014
IN	.0153+-	.0157	.033+-	.034	-016+-	.016
SN	.0719+-	.0228	.155+~	.049	-075+-	.024
SB	6189+-	.0784	1.331+-	- 169 - 171	.649+-	.083
BA LA	.0000+-	.0794 .1313	.000+-	.282	.000+-	.138
	.0000+-			.036	.005+-	.018
HG	0047+-	.0167	.010+-		2.691+-	.191
PB	2.5656+-	.1327	5.516+-	. 285	2.07172	・・・・・・

SAMPLE ID: NEA-009 PARTICLE SIZE: F ANALYSIS ID: MM947 SURFICIAL DUST SAMPLE

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 189.+- 10. MICROGRAMS

ELEMENT	. ne/c	UG/CM2		UG/FILTER		PERCENT	
AL	4.8325+-	.6405	10.370+-	1.377	5.497+-	.784	
SI	14.2895+-	2.1051	30.722+-	4.526	16.255+-	2.544	
F	.2541+-	.0575	.546+-	.124	.289+-	.067	
S	1.4185+-	.2245	3.050+-	.483	1.614+-	.249	
CL	.0000+-	.1059	.000+-	.228	.000+-	.120	
K	.6981+ <del>-</del>	.0815	1.501+-	. 175	.794+-	.102	
CA	2.6385+-	.2976	5. <i>67</i> 3+-	.640	3.001+-	.374	
TI	.3457+-	.0200	.743+-	.043	.393+-	.031	
V	.0330+-	.0055	.071+-	.012	.038+~	.007	
CR	.0500+-	.0042	.108+-	.009	.057+-	.006	
MN	.0964+-	.0064	.207+-	.014	.110+-	.009	
FE	9.0680+-	.4590	19.496+-	.987	10.315+-	.755	
NI	.0435+-	.0039	.094+-	.008	.049+-	.005	
CU	1.3681+-	.0709	2.941+-	.152	1.556+-	.115	
ZN	.2865+-	.0171	.616+-	. 037	.326+-	.026	
GA	.0070+-	.0053	.015+-	.011	-+800.	.006	
AS	3.2408+-	.1824	6.968+-	.392	3.687+-	.285	
SE	.0154+-	.0032	.033+-	.007	.018+-	.004	
BR	.0114+-	.0158	.025+-	.034	.013+-	.018	
RB	.0000+-	.0047	.000+-	.010	-+000+-	.005	
SR	.0184+-	.0027	.040+-	.006	.021+-	.003	
Y	.0120+-	.0060	.026+-	.013	.014+-	.007	
ZR	.0000+-	.0121	.000+-	.026	.000+-	.014	
. MO	.0000+-	.0074	.000+-	.016	.000+-	.008	
PD	.0186+-	.0093	.040+-	.020	.021+-	.011	
AG	.0236+-	.0118	.051+-	.025	.027+-	.013	
CD	.0122+-	.0120	.026+-	.026	.014+-	.014	
IN	.0287+-	.0165	.062+-	.035	.033+-	.019	
SN	.0406+-	.0203	.087+-	. 044	.046+-	.023	
SB	.1830+-	.0575	.393+~	.124	.208+-	. 066	
BA	.1648+-	.0824	.354+~	.177	.187+-	.094	
LA	.0000+-	.1351	.000+	. 290	-000+-	.154	
HG	- 07,56+-	.0269	.163+-	.058	.086+-	.031	
PB	1.4710+-	0772	3.163+-	- 166	1.673+-	.125	

SAMPLE ID: NEA-010
PARTICLE SIZE: F
ANALYSIS ID: MM949
UPPER STACK AREA
EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 111.+- 10. MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT -	
AL	2.8207+-	.3746	6.064+-	.805	5.463+-	.877
SI	8.6730+-	1.2780	18.647+-	2.748	16.799+-	2.901
P	.1085+-	.0250	.233+-	.054	.210+-	.052
S	.3542+-	.0752	.761+ <del>-</del>	.162	. 686+-	. 158
CL	.0000+-	.1197	.000+-	. 257	.000+-	.232 -
ĸ	.4181+-	.0501	.899+-	.108	.810+-	.121
CA	1.2125+-	.1378	2.607+-	.296	2.348+-	.341
ΤI	.1982+-	.0125	.426+-	.027	.384+-	.042
V	-0164+-	.0037	.035+-	.008	.032+-	.008
CR	.0554+-	.0044	.120+-	.009	.108+-	.013
MN	.0610+-	0046	.131+-	.010	.118+-	.014
FE	3.9286+-	.2007	8.446+-	.432	7.609+-	.788
NI	.0445+-	.0040	.096+-	.009	.086+-	.011
CU ·	.5836+-	.0313	1.255+-	. 067	1.130+-	.119 -
ZN	.0879+-	.0067	.193+-	.014	. 174+-	.020
GA	.0043+-	.0023	.009+-	.005	.008+-	.005
AS	3.2268+-	.1658	6.938+-	.356	6.250+-	.648
SE	.0089+-	.0024	.019+-	.005	.017+-	.005
BR	-+0000	.0153	000+-	.033	.000+-	.030
RB	-+0000+-	.0044	.000+-	.009	.000+-	.009
SR	.0059+-	.0024	.013+-	.005	.011+-	.005
Y	.0117+-	.0035	.025+-	.008	.023+-	.007
ZR	-+0000+-	.0124	.000+-	.027	.000+-	.024
MO	-+0000+-	.0074	.000+-	.016	.000+-	.014
PD	-0159+-	.0092	.034+-	.020	.031+-	.018
AG	.0228+-	.0114	-049+-	.025	.044+-	.022
CD	-+0000+-	.0115	.000+-	.025	.000+-	.022
IN	.0173+-	.0166	-037+-	.036	.034+-	.032
SN	.0123+-	.0196	.026+-	.042	.024+-	.038
SB	.4091+-	.0618	.880+-	. 133	.792+-	.139
BA	.0000+-	.0736	.000+-	.158	.000+-	.143
LA	-+0000+-	.1391	.000+-	. 299	.000+-	.269
HG	.0418+-	.0223	.090+-	.048	.081+-	.044
PB	.4553+-	<b>0259</b>	. 979+-	. 056	.882+-	.094

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SAMPLE ID: NEA-011 PARTICLE SIZE: F ANALYSIS ID: MM931

N. SIDE UPPER STACK AREA

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 181.+- 10. MICROGRAMS

ELEMENT	uG/C	UG/CM2		UG/FILTER		PERCENT	
AL	5.7851+-	.7662	12.438+-	1.647	6.872+-	. 984	
SI	13.7940+-	2.0322	29.657+-	4.369	16.385+-	2.578	
P	.2167+-	.0497	.466+-	.107	.257+-	.061	
S	1.0406+-	.1914	2.237+-	.411	1.236+-	.237	
CL	.0000+-	.1538	.000+-	.331	.000+-	.183	
K	.7274+-	.0854	1.564+-	.184	.864+-	.112	
CA	6.3367+-	.7117	13.624+-	1.530	7.527+-	.942	
TI	.4118+-	.0233	.885+-	.050	.489+-	.039	
V	.0250+-	.0058	.054+-	.012	.030+-	.007	
CR	.0438+-	.0039	.094+-	.008	.052+-	.005	
MN	.0922+-	.0062	.198+-	013	.110+-	.010	
FE	6.5406+-	.3320	14.062+-	.714	7.769+-	.583	
NI	.0464+-	.0042	.100+-	.009	.055+-	.006	
CU	.9341+-	.0490	2.008+-	.105	1.110+-	.085	
ZN	.6010+-	.0322	1.292+-	.069	.714+-	.055	
GA	.0068+-	.0056	.015+-	.012	.008+-	.007	
AS	2.8012+-	.1640	6.023+-	.353	3.327+-	.268	
SE	.0123+-	.0029	.026+-	.006	.015+-	.004	
BR	-+0000+-	.0137	-+000+-	.029	.000+-	.016	
RB	.0000+-	.0044	.000+-	.009	.000+-	.005	
SR	.0216+-	.0033	.046+-	.007	.026+-	.004	
Y	.0074+-	.0064	.016+-	.014	.009+-	.008	
ZR	.0000+-	.0149	-000+-	.032	.000+-	.018	
MO	.0117+-	.0098	.025+-	.021	.014+-	.012	
PD	.0223+-	.0113	.048+-	.024	.026+-	.014	
AG	.0280+~	.0140	-+060+-	.030	-+220.	.017	
CD	.0213+~	.0153	.046+-	.033	.025+-	.018	
IN	.0380+~	.0208	.082+-	.045	.045+-	.025	
SN	.0000+-	.0257	.000+-	.055	.000+-	031	
SB	1.6170+-	. 1524	3.477+-	.328	1.921+-	.210	
BA	-+0000+-	.0937	.000+-	.201	.000+-	.111	
LA	.0000+-	. 1653	.000+-	.355	.000+-	. 196	
HG	.0456+~	.0242	.098+-	.052	.054+-	.029	
PB	1.5254+-	.0801	3.280+-	.172	1.812+-	.138	

SAMPLE ID: NEA-012 PARTICLE SIZE: F ANALYSIS ID: MM917 N.W. UPPER STACK AREA

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 157.+- 10. MICROGRAMS

ELEMENT	UG/C	UG/CM2		UG/FILTER		PERCENT	
AL .	3.1415+-	.4172	6.754+-	.897	4.302+-	. 634	
SI -	8.3360+-	1.2284	17.922+-	2.641	11.416+-	1.833	
P	.2511+-	.0568	.540+-	.122	.344+-	.081	
S	1.5032+-	.5186	3.232+-	1.115	2.058+-	.722	
CL -	-+0000+-	.0857	-000+	.184	.000+-	.117	
К -	.5415+-	- 0643	1.164+-	.138	.742+-	.100	
CA	2:2451+-	. 2535	4.827+-	. 545	3.074+-	.399	
TI	.2523+-	.0153	.542+-	.033	.346+-	.030	
V j	.0168+-	.0042	.036+-	.009	.023+-	.006	
CR	.0287+-	.0031	.062+-	.007	.039+-	.005	
MN	.0595+-	.0046	.128+-	.010	.081+-	.008	
FE	5.5675+~	.2831	11.970+-	. 609	7.624+-	.621	
NI	.0208+~	.0028	.045+-	.006	.028+-	.004	
CU	.8725+-	.0459	1.876+-	.099	1.195+-	.099	
ZN	.6673+-	.0354	1.435+-	.076	.914+-	.076	
GA	.0124+~	.0170	.027+-	.037	.017+-	.023	
AS	4.9953+-	.3791	10.740+-	.815	6.841+-	. 678	
SE	.0000+~	.0046	.000+-	.010	.000+-	.006	
BR	.0000+-	.0244	.000+-	.052	.000+-	.033	
RB ~	.0000+~	.0073	.000+-	.016	.000+-	.010	
SR .	.0111+-	.0035	.024+-	.008	.015+-	.005	
Υ -	.0279+-	.0181	.060+-	.039	.038+-	.025	
ZR	.0000+~	.0172	.000+-	. 037	.000+-	.024	
MO	-0053+~	.0103	.011+-	.022	.007+-	.014	
PD	.0256+-	.0128	.055+	.028	.035+-	.018	
AG	.0187+-	.0140	.041+-	.030	.026+-	.019	
CD	.1221+-	.0201	.263+-	.043	.167+-	.030	
IN	.0358+-	.0219	.077+-	.047	.049+-	.030	
SN	.1495+-	.0294	.321+-	.063	.205+-	.042	
SB	.5459+-	.0790	1.217+-	. 170	. <i>77</i> 5+-	.119	
BA	.0000+-	.1013	.000+-	.218	.000+-	- 139	
LA	.0000+-	.1814	.000+-	.390	.000+-	.248	
HG	.0664+-	.0341	.143+-	.073	.091 <del>+-</del>	.047	
PB	5.3479+-	2739	11.498+-	.589	7.324+-	. 599	

SAMPLE ID: NEA-013 PARTICLE SIZE: F ANALYSIS ID: MM939

UPPER STACK AREA - N.E. SIDE

EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 157.+- 10. MICROGRAMS

ELEMENT	r ug/c	M2	UG/FIL	TER	PERCE	ENT .
AL	4.4506+-	.5899	9.569+-	1.268	6.095+-	.896
SI	12.6530+-	1.8641	27.204+-	4.008	17.327+-	2.781
F	.1968+-	.0448	.423+-	.096	.270+-	.064
S	1.1668+-	.2227	2.509+-	. 479	1.598+~	.321
CL	.0163+-	.0348	.035+-	.075	.022+-	.048
K	.6309+-	.0740	1.356+-	.159	.864+~	.115
CA	2.5429+-	.2868	5.467+-	.617	3.482+~	. 451
ŢI	.2602+-	.0156	.559+-	.034	.356+~	.031
V	.0191+-	.0043	.041+-	.009	.026+~	.005
CR	.0272+-	.0029	.058+-	.004	.037+~	.005
MN	.0640+-	.0047	.138+-	.010	.088+-	-009
FE	4.5265+-	.2307	9.732+-	. 476	6.199+-	.506
NI	.0242+-	.0028	.052+-	.006	.033+~	.004
CU	.6002+-	.0321	1.290+-	.069	.822+~	.048
ZN	.3131+-	.0176	. 673+-	.038	.429+-	.036
GA	.0030+-	.0062	-+600.	.013	.004+~	.008
AS	2.5202+-	.1600	5.418+-	.344	3.451+~	.310
SE	.0076+-	.0030	.016+-	.006	.010+-	.004
BR	.0000+-	.0128	.000+-	.028	.000+~	.018
RB	.0000+-	.0040	-+000+-	.009	.000+~	.005
SR	.0142+~	.0027	.031+-	.006	.019+~	.004
Y	.0097+-	.0049	.021+-	.015	.013+~	.009
ZR	.0000+-	.0124	.000+	.027	-000+~	.017
MO	-+0000+-	.0076	-+000+-	.016	.000+-	.010
PD	.0048+-	.0085	.010+-	.018	-007+-	.012
AG	.0000+~	.0113	.000+-	.024	.000+-	.015
CD	.0395+~	0141	.085+-	.030	.054+-	.020
IN	.0205+~	.0166	.044+-	.036	.028+-	.023
SN	.0177+~	.0219	.038+-	.047	.024+-	.031
SB	.2430+-	.0521	.522+-	.112	.333+-	.074
BA	.1056+-	.0798	. 227+-	. 172	.145+-	.110
LA	.0000+-	.1334	-000+-	. 287	.000+-	.183
HG	.0481+~	.0213	.146+-	.046	.093+-	.030
PB	1.7958+-	.0937	3.861+-	.201	2.459+-	.202

SAMPLE ID: NEA-014 PARTICLE SIZE: F ANALYSIS ID: MM919 GODFREY ROASTER

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 140.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	1.4090+-	.1932	3.029+-	.415	2.164+-	. 335
SI	5.1872+-	.7647	11.152+-	1.644	7.966+-	1.305
P.	.1529+-	.0349	.329+-	.075	.235+-	. 056
Sī	1.7616+-	.2334	3.788+-	.502	2.705+-	.407
CL	.0000+-	.1527	.000+-	.328	.000+-	.234
KI 🕟	.3093+-	.0382	<u>.</u> 665+-	.082	.475+-	.068~
CA	2.3402+-	.2641	5.031+-	.568	3.594+-	.480
TI -	.2028+-	.0127	.436+-	.027	.311+-	.030
V	.0135+-	.0036	.029+-	.008	.021+-	.006
CR	.0187+-	.0025	.040+-	.005	.029+-	.004
MN	.0433+-	<b>.</b> 0037	.093+-	.008	.066+-	.007
FE	3.6928+-	.1888	7.940+-	. 406	5.671+-	. 498
NI	.0266+-	.0030	.057+-	.006	.041+-	.005
CU	1.2481+-	.0649	2.683+-	.140	1.917+-	.169
ZN	.2682+-	.0161	.577+-	.035	.412+-	.038
GA	.0000+-	.0042	.000+-	.009	.000+-	.006
AS :	13.3257+-	<u>.</u> 6758	28.650+ <del>-</del>	1.453	20.464+-	1.793
SE	.3864+-	.0256	.831+-	.055	.593+-	.058
BR	.4580+-	.0825	. 985+-	.177	.703+	.136
RB	-+0000+-	.0224	.000+	.048	.000+-	.034
SR	.0374+-	.0036	.080+-	.008	.057+-	.007
Y	.0000+-	.0072	.000+-	.015	.000+-	.011
ZR	.0185+-	.0131	.040+-	.028	.028+-	.020
MO	.0000+-	.0090	.000+-	.019	.000+-	.014
PD	.0000+-	.0138	.000+-	.030	.000+-	.023
AG	.0000+-	.0138	.000+-	.030	.000+-	.022
CD	.0381+-	.0147	.082+-	.032	.059+-	.023
IN	.0282+-	.0187	.061+-	.040	.043+-	.029
SN	·0000+ <del>-</del>	.0239	.000+-	.051	.000+-	.038
SB	2.0811+-	.1353	4.474+-	. 291	3.196+-	. 267
BA	.0204+-	-0869	.044+-	. 187	.031+-	. 133
LA	.2421+-	. 1625	.521+-	.349	.372+-	. 251
HG	1.9590+-	- 4416	4.212+-	. 949	3.008+-	.711
PB	1.0465+-	0558	2.250+-	.120	1.607+-	.143

SAMPLE ID: NEA-015 PARTICLE SIZE: F ANALYSIS ID: MM921 ARSENIC KITCHEN

EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 294.+- 10. MICROGRAMS

ELEMENT	. ne/c	M2	UG/FIL	TER	PERCE	ENT
AL	3.5316+-	. 4729	7.593+-	1.017	2.583+-	.357
SI	11.2530+-	1.6580	24.194+-	3.565	8.229+-	1.244
P	.3063+-	.0693	.659+-	.149	.224+-	.051
S	1.5722+-	.6803	3.380+-	1.463	1.150+~	.499
CL	.0000+-	.1144	.000+-	.246	.000+-	.084
K	.7142+-	.0841	1.536+-	.181	.522+-	.064
CA	4.5181+-	.5081	9.714+-	1.092	3.304+~	.388
TI	.3460+-	.0200	.744+-	.043	.253+-	.017
V	.0302+-	.0054	.065+-	.012	.022+-	.004
CR	.0497+-	.0042	.107+-	- 009	.036+-	.003
MN	.1019+-	.0067	.219+-	.014	.075÷~	.006
FE	10.5892+-	.5355	22.767+-	1.151	7.744+-	. 472
NI	.0654+-	.0052	.141+-	.011	.048+-	.004
CU	3.3113+-	.1691	7.119+-	.354	2.422+-	. 149
ZN	.9898+-	.0534	2.128+-	.115	.724+-	.046
GA	.0459+-	.0226	.099+-	.049	.034+~	.017
AS	21.8211+-	1.1645	46.915+-	2.504	15.958+-	1.010
SE	.2073+~	.0208	.446+-	.045	.152+-	.016
BR	.2430+~	.1092	.522+-	.235	.178+-	.080
RB	.0000+-	.0298	.000+-	.064	.000+-	.022
SR	.0000+-	.0042	.000+-	.009	.000+-	.003
Y	.0000+~	.0248	.000+-	.053	.000+-	.018
ZŔ	-0000+-	.0182	.000+-	.039	.000+~	.013
MO	.0000+~	.0114	.000+-	.025	.000+-	.008
PD	.0000+~	.0219	.000+-	.047	.000+-	.016
AG	.0000+-	.0182	.000+-	.039	.000+-	.013
CD	.0767+~	.0248	.165+-	.053	.056+-	.018
IN	.0706+-	.0207	.152+-	.045	.052+-	.015
SN	-+0000+~	.0373	.000+-	.080	.000+-	.027
SB	2.0811+-	. 2468	4.474+-	.531	1.522+-	.188
BA	.0131+-	.0932	.028+-	.200	.010+-	.068
LA	.0146+-	.1691	.031+-	.364	.011+-	.124
HG	1.0379+-	.2734	2.231+-	.588	.759+-	.202
PB	7.1341+-	3645	15.338+-	.784	5.217+-	.320

SAMPLE ID: NEA-016 FARTICLE SIZE: F ANALYSIS ID: MM951 GODFREY ROASTER - N.

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 381.+- 10. MICROGRAMS

ELEMEN	T UG/C	M2	UG/FIL	TER	PERCE	ENT
AL	7.2929+-	.9689	15.680+-	2.083	4.115+-	.557
SI	20.1723+-	2,9715	43.370+-	6.389	11.383+-	1.703
P	.3713+-	.0840	.798+-	.181	.210+-	.048
S	3.8928+-	.5243	8.369+-	1.127	2.197+-	.301
CL	.0000+-	.1698	.000+-	.365	.000+-	.096
K	1.2161+-	.1402	2.615+-	.301	-686+-	.081
CA	7.3396+-	.8241	15.780+-	1.772	4.142+-	.478
TI	.5433+-	.0300	1.168+-	.045	.307+-	.019
V	.0437+-	.0075	.094+-	.016	.025+-	.004
CR	.0642+-	.0050	.138+-	.011	.036+-	.003
MN	.1550+-	.0093	.333+-	.020	.087÷-	.006
FE	11.1628+-	.5643	24.000+-	1.213	6.299+-	.359
NI	.0750+-	.0057	.161+-	.012	.042+-	.003
CU	3.0858+ <del>-</del>	. 1577	6.634+-	. 339	1.741+-	.100
ZN	1.0951+-	.0583	2.354+-	.125	.618+-	.037
GA	.0000+-	.0078	.000+-	.021	.000+-	.006
AS	27.2310+-	1.3833	58.547+-	2.974	15.367+-	.879
SE	.3241+-	.0254	<b>.</b> 697+−	.055	.183+-	.015
BR	.2177+-	.1316	.46B+ <del>-</del>	. 283	.123+-	.074
RB	.0000+-	.0357	.000+-	. 077	.000+-	.020
SR	.0255+-	.0042	.055+-	.009	.014+-	.002
Y	.0000+-	.0133	.000+-	.029	.000+-	.008
ZR	.0000+-	.0143	.000+-	.031	.000+-	.008
MO	.0317+-	.0087	<b>.</b> 068+-	.019	.018+-	.005
PD	.0000+-	.0236	.000+-	.051	-+000	.013
AG	.0000+-	.0179	.000+-	.038	.000+-	.010
CD .	.0000+-	.0192	.000+-	.041	-000+-	.011
IN	.0000+-	.0185	.000+-	.040	.000+-	.010
SN	.1114+-	.0240	.240+-	.052	.063+-	.014
SB	3.8318+-	.2316	8.238+-	. 498	2.162+-	.142
BA	.0426+-	.0803	.092+-	. 173	.024+-	.045
LA	.0046+-	.1442	.010+-	.310	-003+-	.081
HG	1.4497+-	.3701	3.117+-	.796	.818+-	.210
PB	2.8410+-	.1467	6.108+-	.315	1.603+-	.093

SAMPLE ID: NEA-017 PARTICLE SIZE: F ANALYSIS ID: MM935

GODFREY ROASTER - CENTER AREA EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 205.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	2.9800+-	.3978	6.407+-	.855	3.125+-	. 444
SI	9.5334+-	1.4048	20.497+-	3.020	9.998+-	1.552
P	.1857+-	.0423	.399+-	.091	.195+-	.045
S	2.5637+-	.3216	5.512+-	.691	2.689+-	.362
CL	.0000++	.1595	.000+-	.343	.000+-	.167
K	.5975+-	.0705	1.285+-	.152	.627+-	.080
CA	3.4776+-	.3915	7.477+-	.842	3.647+-	.448
TI	.2824+-	.0168	.607+-	.036	.296+-	.023
V	.0150+-	.0044	.034++	.009	.017+-	.005
CR	.0371+-	.0035	.080+-	.008	.039+-	.004
MN	.0544+-	.0043	.117+-	.009	.057+-	.005
FE	6.2870+-	.3192	13.517+-	. 686	6.594+-	.464
NI	-+0050-	.0032	.065+-	.007	.031+-	.004
CU	1.2592+-	.0654	2.707+-	.141	1.321+-	.094
ZN	.2323+-	.0145	. 499+	.031	.244+-	.019
GA	-+0000+-	.0048	.000+-	.010	.000+-	.005
AS	15.0131+-	.7613	32.279+-	1.637	15.745+-	1.108
SE	.1461+-	.0133	.314+-	.029	.153+-	.016
BR	.1513+-	.0746	.325+-	.160	.159+-	.079
RB	-+0000+-	.0202	.000+-	.043	.000+-	.021
SR	.0064+-	.0034	.014+-	-007	.007+-	.004
Y	.0000+-	.0071	-+000	.015	-000+-	.007
ZR	-0000+-	.0142	.000+-	.031	.000+-	.015
MO	-0000+-	.0087	.000+-	.019	.000+-	.009
PD	-+0000+-	.0139	.000+-	.030	.000+-	.015
AG	.0000+-	.0133	.000+-	.029	.000+-	.014
CD	.0000+-	.0153	.000+-	.033	-000+-	.016
IN	-+0000+-	.0181	.000+-	.039	.000+-	.019
SN	-+0000+-	.0233	-000+-	.050	.000+-	.024
SB	2.0454+-	.1254	4.398+-	. 270	2.145+-	.168
BA	-0000+-	.0846	.000+-	.182	.000+-	.089
LA	.0000+-	.1507	.000+-	.324	.000+-	.158
HG	.9020+-	.2282	1.939+-	- 491	.946+-	.244
PB	1.2009+-	્. 0636	2.582+-	. 137	1.259+-	.091

SAMPLE ID: NEA-018
PARTICLE SIZE: F
ANALYSIS ID: MN377
ENGINEERING WAREHOUSE
EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 155.+- 10. MICROGRAMS

ELEMENT	UG/CM2		UG/FIL	UG/FILTER		PERCENT	
AL	3.2329+-	. 4296	6.951+-	. 924	4.484+-	.662	
SI	8.6631+-	1.2766	18.626+-	2.745	12.017+-	1.933	
₽ ~	.1570+-	.0358	.338+-	.077	.218+-	.052	
S	.8483+-	.1861	1.824+-	.400	1.177+-	.269	
CL	.0619+-	.0335	.133+-	.072	.086+~	. 047	
K	.4778+-	.0571	1.027+-	.123	-4563-	.090	
- CA	2.2428+-	.2532	4.822+-	.544	3.111+-	. 405	
TI	.2669+-	.0160	.574+-	.034	.370+-	.033	
V	.0305+-	.0048	.066+-	.010	042+-	.007	
CR T	.0294+-	.0032	.063+-	.007	. 041+-	.005	
MN -	.0681+-	.0050	. 146+-	.011	.094+-	.009	
FE	4.5976+-	.2343	9.885+-	.504	6.377+-	.524	
NI	.0427+-	.0040	.092+-	.009	.059+-	.007	
CU .	1.4387+-	.0745	3.093+-	.160	1.996+-	. 165	
ZN	.4174+-	.0235	.897+-	.051	.579+	.050	
GA	.0045+-	.0057	.014+-	.012	.009+	.008	
AS	7.7263+-	- 4000	16.612+-	- 860	10.717+-	.887	
SE	.1432+-	.0086		.018	.199+-	018	
BR	.0937+-	.0397	.201+-	.085	.130+	.056	
RB	.0000+-	.0109	.000+-	.023	.000+-	.015	
SR	.0170+-	.0030	.037+-	.006	.024+-	.004	
Υ -	.0000+-	.0069	.000+-	.015	.000+-	.010	
ZR	.0000+-	.0139	.000+	.030	.000+-	.019	
MO	.0082+-	.0092	.018+-	.020	.011+-	.013	
PD	.0230+-	.0115	.049+-	.025	.032+-	.016	
AG	.0044+-	.0119	.009+-	.026	.006+-	.017	
CD	.0638+-	.0162	.137+-	.035	. 088+ <del>-</del>	.023	
IN	.0348+-	.0196	.075+-	.042	.048+-	.027	
SN	.0498+-	. 0249	.107+-	.054	- 069+-	.035	
SB	. 4750+-	. 0889	1.021+-	.191	. 657+-	.130	
BA	.0000+-	.0874	. 000+-	.188	.000+-	.121	
LA	.0000+-	. 1615	.000+-	.347	-000+-	.224	
HG ~	.5919+-	.1197	1.273+-	. 257	.821+-	.174	
PB	1.5918+-	0834	3.422+-	.179	2.208+-	. 184	

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SAMPLE ID: NEA-019 PARTICLE SIZE: F ANALYSIS ID: MM923 N. COOLING POND

EXPOSED AREA: 2.15 SQUARE CM
MASS OF DEPOSIT: 141.+- 10. MICROGRAMS

ELEMENT	ug/c	M2	UG/FIL	TER	PERCE	ENT
AL	4.2370+-	.5617	9.110+-	1.208	6.461+-	.971
SI	11.7169+-	1.7263	25.191+-	3.712	17.866+-	2.921
P	1.5340+-	.3437	3.298+-	.739	2.339+-	.550
S	.4383+-	.0814	.942+-	.175	-468+-	.133
CL	-0000+-	.1016	.000+-	.218	.000+-	. 155
K	.5803+-	.0685	1.248+-	.147	.885+-	.122
CA	3.4555+-	.3890	7.429+-	.836	5.269+-	.701
TI	.2409+-	.0147	.518+-	.032	.367+-	.034
V	.0357+-	.0048	.077+-	.010	.054+-	.008
CR	.0195+-	.0027	.042+-	.006	.030+-	.005
MN	.0426+-	.0037	.092+-	.008	.065+-	.007
FE	3.0067+-	.1543	6.464+-	.332	4.585+-	.401
NI	.0126+-	.0022	.027+-	.005	.019+-	.004
CU	1.2404+-	.0645	2.667+-	.139	1.891+-	.166
ZN	.0620+-	.0073	.133+-	.016	.095+-	.013
GA	.0033+-	.0022	.007+-	.005	.005+-	.003
AS	1.7365+-	.0919	3.733+~	.198	2.648+-	.234
SE	.0343+-	.0038	.074+-	.008	.052+-	.007
BR	.0385+-	.0106	.083+-	.023	.059+-	.017
RB	-+0000+-	.0036	-+000	.008	-+000+-	.005
SR	.0150+-	.0029	.032+-	.006	.023+-	.005
Y	-+050+-	.0037	+600	.008	.005+-	.006
ZR	.0122+-	.0130	.026+-	.028	.019+-	.020
MO	-+0000+-	.0090	.000+-	.019	.000+-	.014
FD	.0066+-	.0099	.014+-	.021	.010+-	.015
AG	.0153+-	.0124	.033+-	.027	.023+-	.019
CD	.0208+-	.0144	.045+-	.031	.032+-	.022
IN	-+0000+-	.0183	-+000+-	.039	.000+-	.028
SN	.0470+-	.0235	.101+-	.051	.072+-	.036
SB	.2083+-	.0556	.448+-	.120	.318+-	.088
BA	.1704+ <del>-</del>	.0941	.366+-	.202	.260+-	.145
LA	-0000+-	.1554	.000+-	.334	.000+-	.237
HG	. 1730+-	.0406	. 372+-	.087	.264+-	.065
PB	. 4349+-	.0250	.935+-	.054	.663+-	.061

SAMPLE ID: NEA-020 PARTICLE SIZE: F ANALYSIS ID: MM925

COOLING POND

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 116.+- 10. MICROGRAMS

ELEMENT	UG/C	M2	UG/FIL	TER	PERCE	ENT
AL	7.7762+-	1,0292	16.719+-	2.213	14.413+-	2.277
SI	8.7187+-	1.2848	18.745+-	2.762	16.160+-	2.759
P	3.5704+-	.7992	7.676+-	1.718	6.618+-	1.587
s	.5227+-	.0955	1.124+-	.205	.969+-	.196
CL -	.0000+-	.1212	.000+-	.261	.000+-	.225
K	.5970+-	.0711	1.284+-	. 153	1.107+~	.163
CA	6.8627+-	.7707	14.755+	1.657	12.720+-	1.801
TI	.2267+-	.0139	.487+-	.030	.420+-	.044
V-	.0286+-	.0044	.061+-	.009	.053+-	.009
CR	.0342+-	.0034	.074+-	.007	.063+-	.008
MN -	.0673+-	.0050	.145+-	.011	.125+-	.014
FE	2.9354+-	.1507	6.311+-	.324	5.441+-	.546
NI -	.0296+~	.0033	-064+-	007 ء	.055+-	.008
CU	2.8191+-	.1442	6.061+-	.310	5.225+-	.524
ZN *	.0621+-	.0130	.134+-	.028	.115+-	.026
GA	.0056+-	.0028	.012+-	.006	.010+-	.005
AS	.8501+-	.0545	1.828+-	.117	1.576+-	.169
SE	.0291+-	.0035	.063+-	.008	.054+-	.008
BR:	.0205+-	.0059	.044+-	.013	.038+-	.011
RB	-+0000+-	.0028	.000+-	. 006	-000+-	.005
SR	.0383+-	.0037	.082+-	.008	.071+-	.009
Y	.0026+-	.0040	-006+-	.009	.005+-	.007
ZR	.0003+-	.0137	.001+-	.029	.001+-	.025
MO	.0000+-	.0097	.000+-	.021	-000+-	.018
PD	-+0000	.0099	.000+-	.021	.000+-	.018
AG	.0544+-	.0145	<u>. 117+-</u>	.031	.101+-	.028
CD	.0162+~	.0148	.035+-	.032	-030+-	.028
IN	.0361+-	.0203	.078+-	.044	.067+-	.038
SN	.0733+~	.0251	.158 <b>+-</b>	. 054	.136+-	.048
SB	.1715+-	.0554	.369+-	.119	.318+-	.106
BA	.1329+-	.0963	.286+-	. 207	.246+-	.180
LA	.1334+-	.1721	. 287 <del>+-</del>	.370	.247+-	.320
HG	.0280+-	.0140	.060+-	.030	.052+-	.026
PB	.5885+~	.0328	1.265+-	.071	1.091+-	.112

SAMPLE ID: NEA-021 PARTICLE SIZE: F ANALYSIS ID: MM937

PARKING LOT N. OF ADMINISTRATION BUILDING

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 150.+- 10. MICROGRAMS

ELEMEN"	T UG/C	M2	UG/FIL	TER	PERCE	ENT
AL	4.6397+-	-6149	9.975+-	1.322	6.650+-	.987
SI	11.6831+-	1.7213	25.119+-	3.701	16.746+-	2.708
F	.8942+-	.2005	1.922+-	.431	1.282+~	.300
S	.6919+-	.1425	1.488+-	.306	.992+-	.215
CL	.0000+-	.0678	.000+-	.146	.000+~	.097
K	.5311+-	.0629	1.142+-	.135	.761+-	.103
CA	2.3010+-	.2597	4.947+ <del>-</del>	.558	3.298+-	.432
ΤI	.3775+-	.0216	.812+-	.046	.541+-	.048
V	.0303+-	.0057	.065+-	.012	.043+-	.009
CR	.0620+-	.0048	.133+ <del>-</del>	.010	.089+-	.009
MN	.0821+-	.0057	.177+-	.012	.118+-	.011
FE	4.3249+-	.2206	9.299+-	.474	6.199+-	.520
NI	.0583+-	.0048	.125+-	.010	.084+-	.009
cn	1.5543+-	.0803	3.342+-	.173	2.228+-	.198
ZN	.1555+-	.0117	.334+-	.025	.223+-	.022
GA	4880.	.0043	.018+-	.009	.012+-	.006
AS	1.5248+-	.0982	3.278+-	.211	2.186+-	.203
SE	.0260++	.0030	.056+-	.006	.037+-	.005
BR	.0000+-	.0083	.000+-	.018	.000+-	.012
RB	-+0000+-	.0031	.000+-	.007	-000+-	.004
SR	.0109+-	.0027	.023+-	.006	.016+-	.004
Y	.0101+-	.0051	.022+-	.011	.014+-	.007
ZR	.0000+-	.0133	.000+-	.029	.000+-	.019
MO	.0075+-	.0088	.016+-	-019	.011+-	.013
PD	-+0000+-	.0105	-+000+-	.023	-+000+-	.015
AG	.0078+-	.0116	.017+-	.025	.011+-	.017
CD	.0066+-	.0134	.014+-	.029	.009+-	.019
IN	.0122+-	.0182	.026+-	.039	.017+-	.026
SN	-+5000.	.0213	.001+-	.046	.000+-	.031
SB	.1327+-	.0520	.285+	.112	.190+-	.076
BA	.0432+-	.0874	.093+-	.188	.062+-	.125
LA	.0000+-	.1517	-+000+-	.326	-000+-	.217
HG	• 0707+ <del>-</del>	.0220	.152+-	.047	.101+-	.032
PB	1.1106+-	<b>. 05</b> 90	2.388+-	.127	1.592+-	.136

SAMPLE ID: NEA-022 PARTICLE SIZE: F ANALYSIS ID: MM927

ROADWAY N. OF POWER HOUSE

EXPOSED AREA: 2.15 SQUARE CM

MASS OF DEPOSIT: 104.+- 10. MICROGRAMS

ELEMENT	UG/CM	12	UG/FIL	TER	PERCE	ENT
AL	_1.6212+-	.2161	3.486+-	. 465	3.352+-	. 551
SI	4.2832+-	.6316	9.209+-	1.358	8.855+-	1.559
F	.3508+-	.0792	.754+-	.170	.725+-	.178
S -	.6597+-	.1049	1.418+-	. 225	1.364+-	. 253
CL -	. QOOQ+	.0675	.000+-	.145	.000+	.140
Κ -	.2230+-	.0296	.479+-	.064	. 461+-	.076
CA -	4.7720+-	.5365	10.260+-	1.153	9.865+~	1.459
TI	.1120+-	.0080	.241+-	.017	.232+~	.028
V	.0085+-	.0026	.018+-	.006	.018+-	.006
CR -	.0199+-	.0024	.043+-	.005	.041+-	.005
MN -	.0381+-	.0034	.082+-	.007	.079+-	.010
FE	2.4647+-	.1271	5.299+-	. 273	5.095+~	. 556
NI	.0327+-	.0033	.070+-	.007	-068+-	.009
CU	1.4549+-	.0753	3.128+-	.162	3.008+-	.328
ZN	.1592+-	.0116	.342+-	.025	.329+-	.040
GA	.0056+-	.0025	.012+-	- 006	.012+-	.005
AS	.9543+-	.0574	2.052+-	.123	1.973+-	.224
SE	.0076+-	.0023	.016+-	.005	.016+-	.005
BR	.0026+-	.0054	.006+-	.012	.005+-	.011
RB	.0000+-	.0024	-000+-	.005	-+000	.005
SR	.0071+-	.0024	.015+-	.005	.015+-	.005
Υ .	.0000+-	.0034	.000+-	.007	-000+-	.007
ZR	.0215+-	.0113	.046+-	.024	.044+-	.024
MO	.0017+-	.0077	.004+-	.017	.004+-	.016
PD	.0167+-	.0091	-036+-	.020	.035+-	.019
AG	- 0430+-	.0122	.092+-	.026	.089+-	.027
CD	.0054+-	.0118	.012+-	.025	:011+-	.024
IN	-+6220.	.0169	.072+-	.036	.069 <del>+-</del>	.036
SN	.0314+ <del>-</del>	.0198	-+860.	.043	.065+-	.041
<b>5</b> 8	. 4723+-	.0651	1.015+-	.140	<u>. 976+-</u>	.164
BA ·	.0000+-	.0752	-000+-	.162	.000+-	. 155
LA	-+0000	.1382	.000+-	. 297	.000+-	. 286
HG ·	.0232+-	.0096	.050+-	.021	.048+-	.020
PB -	.5374+-	.0300	1.155+-	.065	1.111+-	.124

APPENDIX J

SUBSURFACE SOIL

# Subsurface Soils and Slag Results

Subsurface soil and slag results for Phase I and Phase II samples are summarized in the following tables. Analytes which were not detected in any groundwater samples were not included in these tables. Laboratory data packages are available upon request.

Data qualifiers:

NA = not analyzed

#### Summary of Chemical Analysis of Soil and Sing Samples (Phase I)

HC STATION NO: HC SAMPLE NUMBER: SAMPLE DEPTH: MATRIX: GW REGIME:	HW 2A 8-1 10.0 - 14.0 8LAG FILL PLANT	HW 2A 8-3 30.0 - 31.5 GRANULAR FILL PLANT	83A 8-1 10.0-13.0 8LAG FILL PLANT	83A 8-2 20.0 - 21.0 SLAG FILL PLANT	MW 4 8-2 3.5 - 5.0 GRANULAR FILL PLANT	HW 4 8-9 21.0 ~ 22.5 NATIVE SAND PLANT
MISCELLANEOUS RADIATION	PARAMETERS					
GROSS ALPHA (pCi/gram)	4.4 +/-1.6	4.6 +/-1.6	1.8 +/-1.1	4.3 +/-1.6	1.3 +/6	1.1 +/3
TOTAL URANIUM (µg/gran	1.68	1.46	1.59	1.31	0.31	0.16
RADIUM-226 (pCi/gram)	1.29 +/25	1.06 +/47	1.24 +/30	0.69 +/12	0.2	02
TOTAL METALS (in mg/kg DB	)				,	
Antimony	25 U	25 U	25 U	25 U	25 U	25 U
Arsenic .	2640	160	115	100	120	12
Barium	215	46	543	543	34	26
Cedmium	2.5	1.5	0.50 U	0.50	2.5	0.50 U
Chromium	103	138	203	188	44	48
Copper	2355	301	3505	3345	1055	169
Lead	138	191	178	112	132	19
Hercury	0.22	0.25	0.050	0.055	0.65 J	0.08
Nickel	28	55	70	73	151	49
Selenium	1.6	0.75	0.55	0.40	1.2	0.25
Silver	5.5 U	2.5 U	5.0	5.0	13	25 U
Thallium	17 U	5.0 U	17	17	5.0 U	50 U
Zinc	4415	421	5050	7150	181	36

Continued

HC STATION NO:	HW 5	HW 5	MW 6	MW 6	87	87	
HC SAMPLE NUMBER:	<b>\$-3</b>	<b>\$-14</b>	· \$-3	8-5	8-4	8-5	
SAMPLE DEPTH:	6.0 - 7.5	33.5 - 35.0	6.0 - 7.5	11.0 - 12.5	10.0 - 11.0	11.0 - 12.5	
HATRIX:	NATIVE SAND	NATIVE SAND	GRANULAR FILL	NATIVE SILT	NATIVE SILT	NATIVE SILT	
GW REGIME:	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT	
MISCELLANEOUS RADIATIO	N PARAMETERS						
GROSS ALPHA (pCi/gram)	1.3 +/6	1.0 +/6	0.3	0.3	1.0 +/9	1.3 +/~1	
TOTAL URANIUM (µg/gran	0.24	0.05	0.76	0.76	0.99	2.11	
RADIUH-226 (pCi/gram)	02	0.2	02	0.69 +/57	0.79 +/4	0.41 +/~.24	
TOTAL METALS (in mg/kg i	16)						
Antimony	25 U	25 U	25 U	25 U	25 U	25 U	
Arsenic	12	1.9	150	16	240	10	
Barium	22	16	209	36	54	58	
Cadmium	050	0.50	2.5	0.50	6.5 U	0.50	
Chromium	75	50	68	73	97	110	
Copper	83	40	4080	805	363	74	
Lead	19	13	615	32	435	39	
Mercury	0.13	0.12	0.53 J	11.0	0.70	0.13	
Nickel	57	20	110	187	68	81	
Selenium	00.0	0.75	3.3	0.25	22	0.50	
Silver	2.5	25 U	17	25 U	3.5 U	25	
Thallium	5.0 U	5.0 U	5.0 U	5.0 U	8.0	8.0	
Zinc	47	36	785	89	286	105	

## Continued

HC STATION NO: HC SAMPLE NUMBER: SAMPLE DEPTH: HATRIX: GW REGIME:	PTW 8 8-5 10.0 - 11.5 SLAG FILL PLANT	MW 8 \$-13 30.0 - 31.5 NATIVE SILT PLANT	MW 9 C-1 20.0 - 25.5 NATIVE SAND PLANT	MW 9 C-2 25.5 - 29.0 NATIVE SILT PLANT	810 8-3 6.0 - 7.5 GRANULAR FILL PLANT	810 8-7 16.0 - 17.5 GRANULAR FILL PLANT
118CELLANEOUS RADIATION	PARAMETERS					
SROSS ALPHA (pCi/gram)	2.7 +/-2.0	42 +/-22	1.8 +/-1.2	5.2 +/-2.3		03
TOTAL URANIUM (µg/gran	0.5	0.5	0.58	1.00	0.05	1.03
RADIUM-226 (pCI/gram)	3.12 +/27	0.39 +/35	0.99 +/42	1.67 +/58	0.31 +/2	02
(OTAL METALS (in mg/kg 06)	)					
Antimony	25 U	25 U	25 U	25 U	25 U	25 U
Arsenic	635	8.0	200	8.0	900	50
Berium	1770	62	22	74	30	30
Cadmium	8.5	0.50 U	1.0	0.50 U	25	20
Chromium	113	103	61	132	50	75
Copper	1030	60	285	71	491	26
Lead	8950	26	198	26	52	19
Hercury	0.020	0.11	0.39	0.16	0.40	0.15
Nickel	49	86	36	91	- 34	41
Selenium	2.1	0.35	1.2	0.35	0.55	0.30
Silver	10	25 U	25 U	25 U	25 U	25 U
Thallium	21	8.0	5.0 U	8.0	5.0 U	50 U
Zinc	6700	93	770	126	467	76

HC STATION NO: HC SAMPLE NUMBER: SAMPLE DEPTH: MATRIX: GW REGIME:	PW 11 8-2 3.0 - 4.5 GRANULAR FILL STACK	PTW 11 8-6 13.0 - 14.5 NATIVE SAND STACK	PTW 12 8-6 13.5 - 15.0 GRANULAR FILL PLANT	MV 12 \$-14 33.5 - 35.0 NATIVE SAND PLANT	MW 13 8-3 13.5 - 15.0 NATIVE BAND PARKING LOT	MW 13 8-24A 58.5 ~ 59.5 NATIVE BAND PARKING LOT
MISCELLANEOUS RADIATIO	N PARAMETERS					
GROSS ALPHA (pCi/gram)	1.3 +/9	1.6 +/9	0.30	1.5 +/-1.1	0.3	1.1 +/-1
TOTAL URANIUM (µg/gran RADIUM—226 (pCi/gram)	0.17 0.32 +/13	0.55 0.2	0.80 0.23 +/-14	1.34 02	0.17 0.35 +/15	0.56 0.2
TOTAL METALS (in mg/kg D	B)					
Antimony	25 U	25 U	25 U	25 U	25 U	25 U
Arsenic	220	16	22	15	4.0	3.7
Berium	42	22	26	30	34	22
Cedmium	3.5	0.50	2.0	0.50 U	050 U	0.50 U
Chromium	64	62	70	79	59	73
Copper	207 .	32	111	26	24	16
Lead	151	19	52	13	13	6.0
Hercury	1.9	0.29	0.47	0.10	0.075	0.13
Nickel	55	49	47	39	36	31
Selenium	1.8	0.45	0.35	0.45	0.55	0.25
Silver	2.5	. 25 U	25 U	25 U	25 U	25 U
Thallium	0.6	5.0 U	5.0 U	5.0 U	8.0	5.0 U
Zinc	135	47	59	55	42	34

Summary of Chemical Analy							
HC STATION NO:	B-14	B-14	8-14	B-14	8-14	8-15	B-15
HC SAMPLE NUMBER:	8-1	8-2	8-7	3-9	8-15	\$-I	<b>\$-2</b>
SAMPLE DEPTH:	0 - 5	13 - 14.5	25.5 - 27	<b>30.5 - 32</b>	45.5 - 47	0 - 5	10-11
HATRIX:	SLAGFILL	SLAG FILL	8LAG FILL	MATIVE SAND	NATIVE BILT	<b>SLAG FILL</b>	<b>S</b> LAG FILL
6W REGIME:	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT
OTAL METALS (in mg/kg DB)							
Antimony	900. J	NA.	NA	NA	NA NA	513. J	313. J
Arsenic <sup>*</sup>	4850.	NA.	NA	NA	NA	4125.	4875.
Barium	400.	NA	NA	NA	NA	100	105.
Cadmium	19.	NA	NA	NA.	NA	11.	12
Chromium	310.	NA	NA	NA	NA	225.	<b>300</b> .
Copper	13000.	NA	NA	NA	NA	5725.	3750.
Lead	5550.	NA	NA	NA.	NA	3225.	3675.
Mercury	1.85	NA NA	NA.	NA NA	NA NA	1.7	0.4
Nickel	223. J	NA NA	NA NA	NA NA	NA NA	85. J	120. J
Belenium	38.	· NA	NA NA	NA NA	NA NA	2013.	2463.
Silver	43.	NA NA	NA NA	NA NA	NA NA	16.	10.
Thallium	43. 13. U	NA ·	NA NA	NA NA	NA NA	13. U	13. L
inomum Zinc	13. U 20250. J	NA NA	NA NA	NA NA	NA NA	13875. J	16250. J
	2023U. J	INA	NA.	PVA.	INA	13073. 0	10230. 0
P-TOXICITY METALS (In mg/l)	A== 11	414	444	411	414	0.33 U	0.33 (
EPTOX Arsenic	0.33 U	NA NA	NA .	NA	NA NA		
EPTOX Barium	0.5 U	NA 	NA	NA 	NA	0.5 U	0.5 (
EPTOX Cadmium	0.037	NA	NA	NA	NA	0.007	0.025
EPTOX Chromium	0.033 U	NA	NA	NA	NA	0.033 U	0.033 L
EPTOX Lead	0.26	· NA	NA	NA	NA	0.02	0.2
EPTOX Copper	8.6	NA.	, NA	NA	NA	0.72	0.138
EPTOX Zinc	1.5	NA.	NA	NA	NA	2.0	6.9
EPTOX Mercury (in µg/1)	0.5 U	NA	NA	NA	NA	0.5 U	0.5 L
PH	8.5	NA	NA	- NA	NA	5.6	6.0
OLATILE ORGANIC COMPOUNDS (In	т µg/kg DB)						
Benzene	NA NA	20 U	20 U	NA	NA	NA.	NA.
Toluene	NA	20 U	20 U	NA	NA	NA	NA
Ethylbenzne	NA	20 U	20 U	NA	NA	NA	NA
Total Xylenes	NA	20 U	20 U	NA	, NA	NA	NA
EMIYOLATILE ORGANIC COMPOUN	08 (in ma/ka 06)		<del>-</del> , -		•		
Acenapthylene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 L
N-nitrosodiphenyamine	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 t
Phenanthrene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 L
Di-n-butyl phthalate	0.30 N	0.40 N	0.30 N	0.40 N	0.40 N	0.30 U	0.40 L
Fluoranthene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 L
Pyrene	0.30 U	0.10 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
Benzo(a)anthracene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 t
Bis(2-ethylhexyl)phthalate	0.30 N	0.40 N	0.30 N	0.40 N	0.40 U	0.30 U	0.40 L
	0.30 N	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
Chrysene Benzo(b)fluorsnthene		0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
	0.30 U		0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
Benzo(k)fluoranthene	0.30 U	0.40 U		0.40 U	0.40 U	0.30 U	0.40 (
Benzo(a)pyrene	0.30 U	0.40 U	0.30 U		0.40 U	0.30 U	0.40 (
Indeno(1,2,3-cd)pyrene	0.30 U	0.40 U	0.30 U	0.40 U		0.30 U	0.40 (
Benzo(ghi)perylene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U		
a-BHC	NA .	NA DAG	NA	NA O 10 11	NA 0.40.44	NA OZO II	NA 040 I
Retene	0.30 U	0.60	0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
Dimethylanaline	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40
1-methylphenanthrene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
n,n 2-methylphenanthrene	0.30 U	0.40 U	0.30 U	0.40 <sub>,</sub> U	0.40 U	0.30 U	0.40 (
1-methylpyrene	0.30 U	0.40 U	0.30 U	0.40 U	0.40 U	0.30 U	0.40 (
Total Petroleum Hydrocarbons	NA	3600	114 U	58 U	63 U	NA	NA

•		-	 -	
.or	ш	п	•	

C-1 23 - 27 NATIVE SAND PLANT	8-15 50.5 - 52 NATIVE SILT PLANT	8-1 0 - 5 SLAG FILL PLANT	8-3 18 - 19.5 \$LAG FILL PLANT	8-4 23.0 – 24.5 SLAG/8AND PLANT	8-7 30.5 - 32 NATIVE SAND PLANT
13. R	13. R	1236.	· 688. J	25. J	13. N
			7000.		10.
	108.			<b>50</b> .	35.
	0.5 U	18.	13.	1.0	0.5 U
78.	98.	148.	145.	158.	83.
					15.
					13.
					0.03
					43. J
					28.
					25 U
					13. U
					48.
<b></b>	100.	10020- 4	17200. 4	1515. 0	14.
በጃቼ 11	11 880	77	በ ንድስ	በሚያ 11	0.33 U
					0.5 U
					0.003 U
					0.033 U
					0.02
			•		0.017 U
					0.032
					0.5 U
	9.0	42	7.0	5.1	9.1
• • •	•••	•••	***	•••	
					NA NA
					NA .
					NA NA
	NA NA	NA NA	NA	NA	NA
					NA
					NA
					NA
					, NA
					NA
					NA
	NA				NA
	NA			0.40 N	NA NA
NA NA	NA	0.40 U	0.40 U	0.40 U	NA
NA NA	NA				NA
NA	NA				NA
	NA				NA .
	NA NA			0.40 U	NA
	NA	0.40 U		0.40 U	NA
NA	NA	NA	NA.	NA.	NA .
NA	NA	0.40 U		2.3	NA
NA	NA	0.40 U	0.40 U	4.9	NA
NA	NA	0.40 U	0.40 U	0.40 U	NA
NA	NA	0.40 U	0.40 U	0.40 U	NA
#11	ķi.	0.40 11	0.40 11	0.40 11	, NA
	13. R 36. 25. 0.5 76. 25. 23. 0.045 43. J 420. 2.5. U 13. U 53. 0.53. U 0.003. U 0.003. U 0.003. U 0.003. U 0.003. U 0.017 0.073 0.5. U 8.6 In µg/kg DB) NA NA NA NA NA NA NA NA NA NA NA NA NA	NATIVE SAND   NATIVE SILT   PLANT	NATIVE SAND   PLANT	MATIVE SAND   PLANT	MATIVE SAND   PLANT

Continued							
HC STATION NO:	8-17	B-17	B-17	B-17	8-18	B-18	B-18
HC SAMPLE NUMBER:	8-2	8-4	8-16	<b>\$-25</b>	<b>\$-1</b>	8-4	8-11
SAMPLE DEPTH:	2.5 - 4	7.5 - 9	37.5 - 39	60 - 61.5	0 - 1.5	7.5 - 9	25 - 26.5
MATRIX:	NATIVE SAND	NATIVE SAND	NATIVE SILT	NATIVE SAND	GRANULAR FILL	NATIVE SAND	NATIVE SILT
6W REGIME:	STACK	STACK	STACK STACK	STACK	STACK	STACK	STACK STACK
TOTAL METALS (in mg/kg DB)							
Antimony	13. R	13. R	13. R	13. R		13. R	13. R
Arsenic	4.5	12	15.	4.5	3150.	325.	2.3
Barium	35.	35.	48.	43.	<b>80</b> .	73	66.
Cedmium	0.5 U	0.50 U	0.82	0.50 U	<b>33</b> .	4.8	0.5 U
Chromium	43.	43.	63.	45.	55.	75.	83.
Copper	17.	13.	43.	21.	<b>5750</b> .	275.	73.
Lend	11.	9.3	17.	9.3	2100.	200.	17.
Mercury	0.055	0.04	0.165	0.065	60. 70	5.4	0.08
Nickel	43.	60.	70.	46.		70.	80.
Selenium	1.0 U	1.0 U	1.0 U	1.0 U	5.2	1.0 U	1.0 U
Silver	2.5 U	25 U	2.5 U	25 U	<b>23</b> .	2.5 U	25 U
Thallium	13. U	13. U	13. U	13. U	13. U	13. U -	13. U
Zinc	43.	43.	80.	43.	2325.	230.	95.
P-TOXICITY METALS (in mg/1)							
EPTOX Arsenic	0.33 U	0.33 U	0.33 U	NA NA	1.4	0.33 U	0.33 U
EPTOX Barium	0.50 U	0.50 U	0.50 U	NA	0.50 U	0.50 U	0.50 U
EPTOX Cadmium	0.020 U	0.020 U	0.020 U	NA	0.043	0.020 U	0.020 U
EPTOX Chromium	0.033 U	Q.Q33 U	0.033 U	NA	0.033 U	0.033 U	0.033 U
EPTOX Lead	0.020 U	0.020 U	0.020 U	NA	0.020 U	0.020 U	0.020 U
EPTOX Copper	0.017 U	0.017 U	0.017 U	NA	1.8	0.017 U	0.017 U
EPTOX Zinc	0.018	0.017 U	0.017 U	NA	1.2	0.030	0.017 U
EPTOX Mercury (in µg/l)	0.5 U	0.5 U	0.5 U	NA	1.6	0.5 U	0.5 U
pH	6.17	6.16	8.91	NA NA	8.12	5.80	8.26
OLATILE ORGANIC COMPOUNDS		•	0.5				
Benzene	NA NA	NA	NA	NA	NA.	NA	NA
Toluene	NA NA	NA NA	NA NA	NA NA	NA NA	NA.	NA NA
Ethylbenzne	NA NA	NA ·	NA.	NA.	NA NA	NA NA	NA NA
Total Xylenes	NA NA	NA NA	NA NA	· NA	NA NA	NA.	NA NA
SEMIYOLATILE ORGANIC COMPOU		191	101	195	145	164	,,,,
	0.40 U	NA	NA	NA	0.40 U	0.40 U	NA
Acenapthylene		NA NA	NA NA	NA NA	0.40 U	0.40 U	NA NA
N-nitrosodiphenyamine	0.40 U			NA NA	2.57	0.40 U	NA NA
Phenanthrene	0.40 U	NA NA	NA NA		2.57 0.40 U	0.40 U	NA NA
Oi-n-butyl phthalate	0.40 U	NA 	NA ***	NA NA		• • • • • •	
Fluoranthene	0.40 U	NA ***	NA NA	NA	2.83	0.40 U	NA .
Pyrene	0.40 U	NA	NA 1	NA	2.83	0.40 U	NA NA
Benzo(a)anthracene	0.40 U	NA	NA	NA	1.28	0.40 U	NA 111
Bis(2-ethylhexyl)phthalate	0.40 U	NA	NA	NA	0.40 U	0.40 U	NA
Chrysene	0.40 U	NA	NA	NA	1.89	0.40 U	NA
Benzo(b)fluoranthene	0.40 U	NA	NA	NA	0.87	0.40 U	NA.
Benzo(k)fluoranthene	0.40 U	NA	NA	NA	0.99	0.40 U	NA
Benzo(a)pyrene	0.40 U	NA NA	NA	NA.	0.99	0.40 U	NA
Indeno(1,2,3-cd)pyrene	0.40 U	NA	NA.	NA.	0.65	0.40 U	NA
Benzo(ghi)perylene	0.40 U	NA.	NA	NA	0.79	0.40 U	NA
e-BHC	NA	NA.	NA	NA	NA	NA NA	NA
Retene	0.40 U	NA NA	NA NA	NA	0.40 U	0.40 U	NA
Dimethylanaline	0.40 U	NA	NA	NA	0.40 U	0.40 U	NA
1-methylphenanthrene	0.40 U	NÀ	NA	NA	0.40 U	0.40 U	NA
n n 2-methylphenanthrene	0.40 U	NA.	NA	NA	0.42	0.40 U	NA
·····		• • •					
1-methylpyrene	0.40 U	NA	NA	NA	0.40 U	0.40 U	NA

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. Continued							
HC STATION NO:	B-18	B-19	8-19	B-19	B-23	8-23	B-23
HC SAMPLE NUMBER:	8-19	8-2	8-7	8-15	8-1	8-3	3-10
SAMPLE DEPTH:	45 - 46.5	25-4	15 - 16.5	<b>35 - 36.5</b>	0 - 1.5	5 - 6.5	22.5 - 24
HATRIX:	NATIVE SAND	GRANULAR FILL	NATIVE SAND	NATIVE SOIL	GRANULAR FILL	GRANULAR FILL	NATIVE SILT
6W REGIME:	STACK	STACK	8TACK	STACK	PLANT	PLANT	PLANT
TOTAL METALS (in mg/kg D6)		· · · · · · · · · · · · · · · · · · ·					
Antimony	. 13. R	13. R	13. R	13. R	213. J	13. R	13. R
Arsenic	3.	<b>475</b> .	7.8	12	11000.	2575.	7.3
Barium	35.	<b>75</b> .	40.	<b>53</b> .	113.	95.	95.
Cadmium	0.5 U	7.3	7.3	0.5 U	<b>268</b> .	98.	0.5 U
Chromium	40.	<b>45</b> .	43.	63.	75.	108.	93.
Copper	17.	<b>38</b> .	165.	40.	4175.	1588.	<b>58</b> .
Lead	73	<b>375</b> .	9.3	20.	6050.	158.	<b>25</b> .
Mercury	0.035	8.8	0.055	0.07	<b>56</b> .	1.15	0.1
Nickel	40	45.	43.	68.	70. J	90. J	85. J
Selenium	1.0 U	1.0 U	43.	1.0 U	40.0	25.0	15.0
Silver	25 U	2.5 U	25 U	25 U	24.	25 U	2.8
Thellium	13 U	13. U	13. U	13. U	13. U	=	13. U
Zinc	43.	<b>300</b> .	<b>400</b> .	.08	1 <b>5</b> 00. J	1975. J	103.
EP-TOXICITY HETALS (in mg/l)							
EPTOX Arsenic	0.33°U	0.33 U	0.33 U	0.33 U	11	6.7	0.33 U
EPTOX Barium	0.50 U	0.50 U	0.50 U	0.50 U	0.5 U		0.5 U
EPTOX Codmium	0.020 U	0.020 U	0.042	0.020 U	0.103	0.292	0.003 U
EPTOX Chromium	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U
EPTOX Lead	0.020 U	0.020 U	0.020 U	0.020 U	0.05	0.02	0.02
EPTOX Copper	0.023	0.017 U	0.084	0.017 U	0.70	3.3	0.018
EPTOX Zinc	0.025	0.058	2.0	0.065	0.50	8.3	0.025
EPTOX Mercury (in µg/1)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
pH	8.76	6.56	5.53	7.25	5.8	4.4	8.8
<b>VOLATILE ORGANIC COMPOUNDS (</b>	in µg/kg OB)						
8enzene -	NA	NA.	NA	NA	NA	NA	NA.
Toluene	NA	NA	NA	NA	NA	NA	NA
Ethylbenzne	NA	NA.	NA	NA	NA -	NA NA	NA
Total Xylenes	NA	NA	NA	NA	NA	NA	NA.
SEMIVOLATILE ORGANIC COMPOU	KDS (in mg/kg DS)						
Acenapthylene	NA	0.40 U	NA	NA	0.40 U	0.50 U	0.40 U
N-nitrosodiphenyamine	NA	0.40 U	NA	NA	0.40 U	0.50 U	0.40 U
Phenanthrene Phenanthrene	NA	0.40 U	NA	NA	1.01	0.50 U	0.40 U
Di-n-butyl phthalate	NA	0.44	NA	NA	0.40 N	0.50 N	0.40 N
Fluoranthene	NA	0.40 U	NA	, NA	1.05	0.50 U	0.40 U
Pyrene	NA	0.40 U	NA	NA	1.30	0.50 U	0.40 U
Benzo(a)anthracene	NA	0.40 U	NA	NA	0.57	0.50 U	0.40 U
Bis(2-ethylhexyl)phthalate	NA	0.40 U	NA	NA	0.40 U	0.50 U	0.40 U
Chrysene	NA	0.40 U	NA NA	NA.	0.90	0.50 U	0.40 U
Benzo(b)fluoranthene	NA	0.40 U	NA	NA	0.40 U		0.40 U
Benzo(k)fluoranthene	NA	0.40 U	NA	NA	0.40 U		0.40 U
Benzo(a)pyrene	NA.	0.40 U	NA	NA	0.51	0.50 U	0.40 U
Indeno(1,2,3-cd)pyrene	NA	0.40 U	NA:	NA	0.40 U		0.40 U
Benzo(ghi)perylene	NA ·	0.40 U	NA	NA	0.40	0.50 U	0.40 U
a-BHC	NA	NA	NA	NA	NA	NA.	NA
Retene	NA	0.40 U	NA 111	NA	0.40 U		0.40 U
Dimethylanaline	NA	0.40 U	NA	NA	0.40 U		0.40 U
1-methylphenanthrene	NA 111	0.40 U	NA	NA Att	0.40 U		0.40 U
n,n 2-methylphenanthrene	NA 111	0.40 U	NA.	NA ***	0.40 U		0.40 U
1-mathilograph	hr	0.40 11	_ NA	NA 111	0.40 11		. 0.40 U
Totarenoleumnyuvcerbase	M	- N	N	NA	NA	NA	

Continued B-25 B-25 B-25 B-25 B-26 B-24 8-24 HC STATION NO: 3-4 9-9 8-14 8-4 HC SAMPLE NUMBER: 8-1 8-5 3-1 0 - 1.513.0 - 14.5 20 - 21.5 32.5 - 3437.5 - 39 SAMPLE DEPTH: 3-4.5 13 - 14.5**NATIVE SILT NATIVE SILT GRANULAR FILL GRANULAR FILL GRANULAR FILL NATIVE SAND** NATIVE SILT **MATRIX**: **COOLING POND** COOLING POND **PARKING LOT COOLING POND COOLING POND 6W REGIME:** PLANT **PLANT** TOTAL METALS (in mg/kg DB) 13. R 13. R 13. R 13. R 13. R 13. R 13. R **Antimony** 265. 16. 27. 3.8 33. 29. 8.1 Arsenic 78. 73. 65 38. 93. 103. 93. Barlum 2.3 0.5 U 0.5 0.5 U Codmium 12 1.0 3.5 83. 88 65 24. 103. 100. 118. Chromium 60. 55. 1250. 63. 40. 23 43. Copper 23. 23. 243. 23. 63. 10 9.3 Lead 235 0.125 0.35 0.035 0.085 0.4 0.095 Mercury 78. J 60. J 60. J 40 J 25 86. J 90. J Nickel 25. 18. 25. 25 1.0 U Selenium 145.0 28. 4.5 2.5 U 25 U 25 U 25 U 25 U 2.5 U Silver 13. U 13. U 13. U 13 U 13. U Thallium 13. U 13. U **5**Q 223. 68. 80. 43 Zinc 105. 105. EP-TOXICITY METALS (in mg/1) 0.33 U 0.33 U 0.33 U 0.33 U 0.33 U 033 U 033 U **EPTOX Arsenic** 0.5 U 0.5 U 0.5 U 0.5 U 0.5 U 0.50 U **EPTOX Barium** 0.5 U 0.003 U 0.003 U 0.020 U 0.010 0.003 U 0.003 U **EPTOX Codmium** 0.003 U 0.033 U 0.033 U 0.033 U 0.033 U 0.033 U 0.033 U 0.033 U **EPTOX Chromium EPTOX Lead** 0.02 U 0.02 0.03 0.03 0.02 0.02 0.020 U 0.147 0.017 U 0.017 U 0.017 U 0.017 U 0.017 U 0.017 U **EPTOX Copper** 0.023 0.033 0.08 0.017 0.022 **EPTOX Zinc** 0.017 0.022 0.5 U 0.5 U 0.5 U 0.5 U 05 U 0.5 U 0.5 U EPTOX Mercury (in µg/1) 5.9 8.2 6.5 6.3 6.7 566 рΗ 6.1 YOLATILE ORGANIC COMPOUNDS (in µg/kg DB) NA NA NA NA NA Benzene NA NA NA NA NA NA NA NA NA Toluene NA NA NA NA NA NA NA Ethylbenzne NA NA NA NA NA NA NA **Total Xylenes** SEMIYOLATILE ORGANIC COMPOUNDS (in mg/kg DB) 0.40 U NA NA NA 0.40 U NA 0.30 U Acenzothylene 0.40 U NA 0.30 U 0.40 U NA NA NA N-nitrosodiphenyamine 0.30 U 0.40 U NA NA NA Phenanthrene 0.40 U NA NA NA NA 0.30 N 0.40 N Di-n-butyl phthalate 0.67 J NA 0.40 U NA .NA NA Fluoranthene 0.40 U NA 0.30 U NA NA NA Pyrane 0.40 U NA 0.30 U 0.40 U NA NA 0.30 U 0.40 U NA 0.40 U NA Benzo(a)anthracene 0.40 U NA NA NA NA 0.30 U Bis(2-ethylhexyl)phthalate 0.40 N NA NA NA Chrysene 0.40 U NA 0.30 U 0.40 U NA NA 030 U 0.40 U NA Benzo(b)fluoranthene 0.40 U NA 0.30 U 0.40 U NA NA NA Benzo(k)fluoranthene 0.40 U NA 0.30 U 0.40 U NA NA NA Benzo(a)pyrene 0.40 U NA NA NA NA 0.30 U 0.40 U Indeno(1,2,3-cd)pyrene 0.40 U NA 0.30 U 0.40 U. NA NA NA Benzo(ghi)perylene 0.40 U NA NA NA NA a-BHC NA NA NA NA NA NA NA NA 0.30 U 0.40 U 0.40 U Retene 0.30 U 0.40 U NA NA NA NA Dimethylanaline 0.40 U NA 0.30 U 0.40 U NA. NA 1-methylphenanthrene 0.40 U NA NA NA NA 0.30 U 0.40 U 0.40 U NA nin 2-methylphenanthrene NA NA NA NA 0.30 U 0.40 U 0.40 U 1-methylpyrene NA NA NA NA NA NA NA Total Petroléum Hydrocarbons

Continued HC STATION NO:	B-26	8-27	B-27	B-27	B-27	B-27	8-28
HC SAMPLE NUMBER:	8-6	8-1	8-4	8-12	8-22	8-27	8-1
SAMPLE DEPTH:	425-435	0-1.5	7.5 - 9	27.5 - 29	525 - 53.5	65 - 65.5	0-1.5
MATRIX:	NATIVE PEAT	GRANULAR FILL	NATIVE SAND	NATIVE SAND	NATIVE SAND	NATIVE SAND	GRANULAR FILL
6W REGIME:	PARKING LOT	PARKING LOT	PARKING LOT	PARKING LOT	PARKING LOT	PARKING LOT	PARKING LOT
TOTAL METALS (in mg/kg DB)	PARKING LOT	PARKINGLOI	FARRING EGT	TANKING EUT	TARKING EGT	TARRING EGT	TANKING EG!
Antimony	13. R	40. J	13. R	13. R	13. R	13. R	13.6
Arsenic	7.5	245.	7.3	2.5	1.0	2.3	18.
Barium	30.	<b>55</b> .	60.	45.	40.	36.	75.
Cadmium	0.83	1.9	0.5 U	0.5 U	0.5 U	0.5 U	
Chromium	24	48.	<b>55</b> .	28.	35.	73	78.
Copper	33.	900.	<b>55</b> .	20.	22	25.	95.
Lead	11.	198.	17.	9.3	9.3	9.3	33.
Mercury	0.055	0.4	0.245	0.035	0.04	0.05	0.16
Nickel	20. '	40.	43.	25.	24.	33	
Selenium	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 (
Silver	25 U	3.5	25 U	25 U	25 U	25 U	3.8
Thailium	13.0	13. U	13. U	13. U	13. U	13. U	
Zinc	45.	775.	70.	50	45.	40.	110.
EP-TOXICITY METALS (in mg/l)							•
EPTOX Arsenic	0.33 U	0.33 U	0.33 U	0.33 U	0.33 U	0.33 U	0.33 (
EPTOX Barium	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 (
EPTOX Cadmium	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 (
EPTOX Chromium	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U	0.033 (
EPTOX Lead	0.020 U	0.022	0.020 U	0.020 U	0.020 U	0.020 U	0.020 (
EPTOX Copper	0.017 U	0.11	0.017 U	0.017 U	0.017 U	0.017 U	0.017 (
EPTOX Zinc	0.017 U	0.11	0.018	0.017 U	0.017 U	0.017 U	0.037
EPTOX Mercury (in µg/1)	0.\$ U	0.5 U	0.5	0.5 U	0.5 U	0.5 U	0.5 (
pH	5.73	5.65	5.92	6.58	5.82	5.74	6.49
VOLATILE ORGANIC COMPOUNDS							
Benzene	NA	NA	NA	NA	NA.	NA	NA
Toluene	NA.	NA	NA.	NA	, NA	NA	NA
Ethyibenzne	NA	NA	NA	NA	NA	NA	NA
Total Xylenes	NA	NA	NA	NA	NA	NA.	NA
SEMIVOLATILE ORGANIC COMPOU	MDS (in mg/kg DS)	1					
Acenapthylene	Ň	0.40 U	0.40 U	NA	NA	NA	NA
N-nitrosodiphenyamine	NA	0.40 U	0.40 U	NA	NA NA	NA	NA.
Phenanthrene	NA	0.40 U	0.40 U	NA	NA	NA	NA
Di-n-butyl phthalste	NA	0.40 U	0.40 U	NA	NA	NA	NA
Fluoranthene	NA	0.40 U	0.40 U	NA	NA NA	NA.	NA
Pyrene	NA	0.40 U	0.40 U	NA	NA.	NA.	NA
Benzo(a)anthracene	NA	0.40 U	0.40 U	NA	NA.	NA	NA
Bis(2-ethylhexyl)phthalate	NA	0.40 U	0.40 U	NA	NA	i NA	NA
Chrysene	NA	0.40 U	0.40 U	NA	NA ;	, NA	NA
Benzo(b)fluoranthene	NA	0.40 U	0.40 U	NA.	NA '	NA.	NA
Benzo(k)fluoranthene	NA	0.40 U	0.40 U	NA	NA	NA	, NA
Benzo(a)pyrene	NA	0.40 U	0.40 U	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	0.40 U	0.40 U	NA	NA	NA	NA
Benzo(ghi)perylene	NA .	0.40 U	0.40 U	NA .	NA	NA All	NA .
a-BHC	NA	NA .	NA	NA .	NA	NA	NA .
Retene	NA NA	0.40 ป	0.40 U	NA .	NA NA	NA.	NA.
Dimethylanaline	NA	0.40 U	0.40 U	NA NA	NA NA	NA NA	NA .
1-methylphenanthrene	NA NA	0.40 U	0.40 U	NA 411	NA A	NA Ali	NA .
n,n 2-methylphenanthrene	NA .	0.40 U 0.40 ''	0.40 U	NA 111	NA NA	NA Ala	NA .
1-r	NA NA	NA.	0.4r ''	NA NA	NA NA	NA NA	NA

Continued B-29 B-29 8-29 B-29 HC STATION NO: 5-28 B-28 8-28 8-5 8-6 C-I 8-I 8-5 8-7 8-13 HC SAMPLE NUMBER: 25 - 28 0 - 1.510-11.5 15-16.5 30 - 31.5SAMPLE DEPTH: 10-115 12.5 - 13.5**NATIVE SAND NATIVE SAND MATRIX**: NATIVE SILT **NATIVE SAND NATIVE SAND GRANULAR FILL NATIVE SAND PARKING LOT 6W REGIME: PARKING LOT PARKING LOT PARKING LOT PARKING LOT PARKING LOT PARKING LOT** TOTAL METALS (in mg/kg 08) 13. R 13. R 18. J 103. J 13. R 13. R 13. R **Antimony** 6.5 1.5 1175. 3.8 2.3 2.3 Arsenic 11. 63. 48. 40. 80. 45. 45. 35. Barium 0.7 0.50 U 0.70 3.8 0.58 0.50 U 0.50 U Cadmium **30**. 60. 35. 75. 133. 53. 60. Chromium 48. 2750. 33. 30. 28. 35. 15 Copper 15. 15. 11. 73 900. 11. 11. Lead 0.035 1.3 0.15 0.055 0.035 0.12 0.06 Mercury 35. 60. **30**. 45. 100. 40. 40. Nickel 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U Selenium 25 U 25 U 25 U 25 U 25 U 25 U 8.5 Silver 13. U 13. U 13. U 13. Ü 13. U 13. U 13. U Thallium 73. 53. 43. 2500. 45. 48. 48. Zinc EP-TOXICITY METALS (in ma/1) 0.33 U 0.33 U 0.33 U 0.33 U 0.68 0.33 U **EPTOX Arsenic** 0.33 U **EPTOX Barlum** 0.50 U 0.50 U 0.50 U 0.50 U 0.50 U 0.50 U 0.50 U 0.020 U 0.020 U 0.020 U 0.020 U 0.020 U 0.020 U 0.020 U **EPTOX Codmium** 0.033 U 0.033 U 0.033 U 0.033 U 0.033 U 0.033 U 0.033 U **EPTOX Chromium** 0.020 U 0.020 U 0.020 U 0.020 U 0.020 U 0.020 U **EPTOX Lead** 0.020 U 0.72 0.017 U 0017 U 0017 U **EPTOX Copper** 0.017 U 0.017 U 0.017 U 0.017 U 0.017 U 0.017 U 0.60 0.017 U 0.017 U 0.045 **EPTOX Zinc** 0.5 U 0.5 U 0.5 U 0.5 U 0.5 U 0.5 U 0.5 U EPTOX Mercury (in µg/l) 5.38 6.02 5.12 5.48 5.46 5.89 5.72 YOLATILE ORGANIC COMPOUNDS (In µg/kg OB) NA NA NA NA NA NA Benzene NA NA NA NA NA NA NA Toluene NA NA NA NA Ethylbenzne NA NA NA NA NA NA NA NA NA NA Total Xylenes SEMIYOLATILE ORGANIC COMPOUNDS (In mg/kg DB) NA NA NA NA NA NA Acenapthylene NA NA NA NA NA N-mitrosodiphenyamine NA NA NA NA NA NA NA NA NA Phenanthrene NA NA NA NA NA NA NA Di-n-butyl phthalate NA NA NA NA NA NA NA Fluoranthene NA NA NA NA NA NA NA Pyrene NA NA NA NA Benzo(a)anthracene NA NA NA NA NA Bis(2-ethylhexyl)phthalate NA NA NA NA NA NA NA NA NA NA NA NA Chrysene NA NA NA NA Benzo(b)fluoranthene NA NA NA NA NA NA NA NA NA Benzo(k)fluoranthene NA NA NA NA NA NA NA NA Benzo(a)pyrene NA NA NA NA NA NA Indeno(1,2,3-cd)pyrene NA NA NA NA NA NA NA NA Benzo(ghi)perylene a-BHC NA NA NA NA NA NA NA ŇA NA NA NA NA NA Retene NA NA NA NA NA NA NA NA Dimethylandline NA NA NA NÁ NA NA NA 1-methylpheranthrene ŇÀ NÁ NA ŇÅ NA NA n.n.2-methylphenanthrene NA NA NÁ ÑÁ ŇÁ ŇΑ NA NA 1-methylpyrene NA NA ŇÅ NA NÀ NA NA Total Pétroleum Hydrocarbons

C--41---

## ## ## ## ## ## ## ## ## ## ## ## ##	Continued		1					
### 125-14   125-14   125-14   125-14   125-14   125-12	*	B-31	B-31	8-31	B-33	B-33	8-33	B-33
### MATTER GRANAL AR FILL    STACK   STACK   STACK   STACK   STACK   PLANT   PLANT   PLANT   PLANT   PLANT   PLANT	. HC SAMPLE NUMBER:	8-2	8-6			8-9	8-10	
TOTAL RETALS (In mp/19   DEAT   DEAT   DEAT   DEAT   DEAT	- · · · · · · · · · · · · · · · · · · ·			22.5 - 24				
TOTAL FET FALS (1 in mg/kg 06) Antinorey Antin	MATRIX: GR							
Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Arsimory  Bertum  78 108 05 13 10 10 MA MA MA NA MA MA MA MA MA MA MA MA MA MA MA MA MA		STACK	STACK	STACK	PLANT	<u> PLANT</u>	PLANT	<u> Plant</u>
### Spring	<b>-</b>				***	***		***
Barium	<b>▼</b>				· · · ·			
Codmism   3.8   0.5 U   0.5 U   NA								
Cryomium   33								
Copper								
Lead								
Hercury 0.3 0.106 0.075 NA NA NA NA NA NA NA Selentum 30. 30. 30. 23. NA NA NA NA NA NA Selentum 30. 30. 23. NA NA NA NA NA NA Selentum 30. 30. 25. NA NA NA NA NA NA NA SELECTUM SELEC	• •							•
Mickel	<del>-</del>							
Selentum   30   30   23   NA	•							
Silver								
Thaillum 13 U 13 U 13 U NA NA NA NA NA NA NA NA NA NA NA NA NA								
2 10c								
EPTOX Insente								
EPTOK Arsenic		,,,,,	770.	<b>~</b> 0.	,,,			
EPTOX farium		033 U	033 U	033 U	NA.	NA	NA	NA
EPTOX Cedmlurn								
EPTOX Circomium         0.033 U         0.033 U         0.033 U         NA         NA         NA         NA         NA         NA         PA         NA	- 1-11		0.003 U	0.003 U	NA	NA	NA	NA
BPTOX Lend			0.033 U	0.033 U	NA	NA		
EPTOX Zine	EPTOX Lead			0.03	NA	NA	NA	NA
EPTOX   Inc	EPTOX Copper	0.033	0.017 U	0.02	NA	NA	NA.	NA
PH 5.5 8.8 8.6 NA NA NA NA NA NA NA VOLATILE ORGANIC COMPOUNDS (in µg/kg DB)  Benzene NA NA NA NA NA NA 20 U 20 U 10 NA Toluene NA NA NA NA NA NA NA 20 U 20 U 10 NA Ethylbenzne NA NA NA NA NA NA NA 20 U 20 U 10 NA NA Ethylbenzne NA NA NA NA NA NA 20 U 20 U 10 NA NA NA NA NA NA 100 U 10 U 10 NA NA NA NA NA NA NA 100 U 10 U 10 NA NA NA NA NA NA NA NA NA NA NA NA NA		0.077	0.022	0.102	NA	NA.	NA	NA.
VOLATILE ORGAMIC COMPOUNDS (in μg/kg DS)           Berzene         NA         NA         NA         NA         NA         20 U         20 U         20 U         NA           Toluene         NA         NA         NA         NA         NA         NA         20 U         20 U         NA           Ethylbenzne         NA         NA         NA         NA         NA         NA         20 U         20 U         NA           SEHIVOLATILE ORGANIC COMPOUNDS (in mg/kg DS)         NA         NA         NA         NA         NA         20 U         20 U         NA           Acenspthylene         NA         NA         NA         NA         NA         0.40 U         0.	EPTOX Mercury (in µg/1)	0.5 U	0.5 U	Q.5 U	NA	NA	NA	NA
Benzene	pH	5.5	8.8	8.6	NA	NA	NA.	NA
Tollene NA NA NA NA NA NA 20 U 20 U NA NA Ethylbenzne NA NA NA NA NA NA 20 U 20 U NA SEHIVOLATILE DRGANIC COMPOUNDS (ia mag/kg D8)  Acenapthylene 0.40 U NA NA NA 030 U 0.40 U 0.	VOLATILE ORGANIC COMPOUNDS (In	µg/kg D6)				•		
Ethylbenzne NA NA NA NA NA 20 U 20 U NA Total Xylerea NA NA NA NA NA NA NA NA NA NA NA NA NA	Benzene							
Total Xylenes NA NA NA NA NA NA 20 U 20 U NA SEMIYOLATILE DRGANIC COMPOUNDS (in mar/kg DE)  Acenspthylene 0.40 U NA NA 0.30 U 0.40 U 0.								
SEMIYOLATILE DRGANIC COMPOUNDS (in mg/kg DB)  Acerapthylene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U  N-mitrosodiphenyamine 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U  Phenanthrene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U  Di-m-butyl phthalate 0.40 N NA NA 0.30 N 0.40 N 0.40 N 0.40 N  Fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U  Benzo(a)anthracene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U  Benzo(a)anthracene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U  Bis(2-ethylhexyl)phthalate 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40 U 0.40 U  Benzo(b)fluoranthene 0.40 U NA NA NA 0.30 U 0.40 U 0.40								
Acenapthylene			NA	NA	NA	20 U	20 U	NA
N-nitrosoctiphenyamine				414				242.1
Phenanthrene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 0.40 U 0.40 U 0.40 U 0.40 U 0.40 U 0.40 N Fluoranthene 0.40 N NA NA 0.30 N 0.40 N 0.40 N 0.40 N 0.40 N 0.40 N 0.40 N 0.40 N 0.40 N 0.40 N 0.40 U	• •							
Di-m-butyl phthalate								
Fluoranthene 0.40 U NA NA 0.30 U 0.40								
Pyrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(a)anthracene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Bis(2-ethylhexyl)prithalate         0.40 U         NA         NA         0.30 N         0.40 N         0.40 U         0.40 U           Chrysene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(b/fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(k)/fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(k)/fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(k)/fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(k)/fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(k)/fluoranthene         0.40 U         NA         NA<	• •							
Benzo(a)anthracene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Bis/2-ethylhexyl)phthalate         0.40 U         NA         NA         0.30 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 N         0.40 U	_ 17							
Bis(2-ethylhexyl)phthalate	•							
Chrysene 0.40 U NA NA 0.30 U 0.40 U 0								
Benzo(b)fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0	<b>.</b>							
Benzo(k) fluoranthene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(a)pyrene         0.40 U         NA         NA         0.30 U         0.40								
Benzo(a)pyrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Indeno(1,2,3-cd)pyrene         0.40 U         NA         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Benzo(ghi)perylene         0.40 U         NA         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           a-BHC         NA         NA         NA         NA         NA         NA         0.022         NA           Retene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Dimethylanaline         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           n,n 2-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-r         'byren         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U								
Benzo(grii)perylene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           a-BHC         NA         NA         NA         NA         NA         0.022         NA           Retene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           Dimethylanaline         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           n,n 2-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U	Benzo(a)pyrene		NA.	NA	0.30 U	0.40 U	0.40 U	0.40 U
Benzo(ghi)perylene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           a-BHC         NA         NA         NA         NA         NA         0.022         NA           Retene         0.40 U         NA         NA         0.30 U         0.40 U <th< td=""><td>Indeno(1,2,3-cd)pyrene</td><td>0.40 U</td><td>NA.</td><td>NA</td><td>0.30 U</td><td>0.40 U</td><td>0.40 U</td><td>0.40 U</td></th<>	Indeno(1,2,3-cd)pyrene	0.40 U	NA.	NA	0.30 U	0.40 U	0.40 U	0.40 U
a-BHC         NA         NA         NA         NA         NA         0.022         NA           Retene         0.40 U         NA         NA         0.30 U         0.40 U <t< td=""><td></td><td>0.40 U</td><td>NA</td><td>NA</td><td>0.30 U</td><td>0.40 U</td><td>0.40 U</td><td>0.40 U</td></t<>		0.40 U	NA	NA	0.30 U	0.40 U	0.40 U	0.40 U
Dimethylanaline         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           n,n 2-methylphenanthrene         0.40 U         NA         NA         0.30 U         0.40 U         0.40 U         0.40 U           1-m         'pyrer         0.40 U         NA         NA         0.30 U         0.40 U         -0.40 U         0.40 U	a-BHC	NA	NA.	NA		NA	0.022	
1-methylphementhrene 0.40 U NA NA 0.30 U 0.40 U								
n,n 2-methylphenanthrene 0.40 U NA NA 0.30 U 0.40 U 0.40 U 0.40 U 1-m 'byrer 0.40 U 0.40 U 0.40 U 0.40 U 0.40 U								
1-r ' 'pyrer								
Total Petroleum Hydrocarbons NA Na Na Na S3 U 200 320 3		-						
	Total Petroleum Hydrocarbons	NA	No.	N <sub>2</sub>	55 U ~	200		

Continued							
HC STATION NO:	B-34	B-34	B-34	8-35	8-35	8-35	B-36
HC SAMPLE NUMBER:	8-2	8-4	8-6	8-4	8-6	3-6	8-1
SAMPLE DEPTH:	10.5 - 12	20.5 - 22	28 - 29.5	20.5 - 22	<b>30.5 - 32</b>	<b>35.5 - 37</b>	0 - 5
MATRIX:	8LAG FILL	SLAG FILL	SLAG FILL	SLAG FILL	8LAG FILL	NATIVE SAND	SLAG FILL
6¥ REGIME:	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT
TOTAL METALS (in mg/kg D6)		***				414	0075 1
Antimony	13. R	NA 	355. J	NA ***	NA ***	· NA	2275. J
Arsenic	1450.	NA ***	3625.	NA NA	NA NA	NA NA	9000. 600.
Barium	83. 12.	NA NA	425.	NA NA	NA NA	NA NA	16.
Cadmium	12 120.	NA NA	14. 103.	NA NA	NA NA	NA NA	288.
Chromium Copper	120. 2900.	NA NA	2925.	NA NA	NA NA	NA NA	8750.
Lead	3750.	NA NA	6200.	NA.	NA.	NA NA	9750.
	0.03	NA NA	0.025 U	NA NA	NA NA	NA NA	0.9
Mercury Nickel	80. J	NA NA	763. J	NA NA	NA NA	NA NA	170. J
Selenium	95.	NA NA	25.	NA NA	NA NA	NA NA	10.
Silver	7.5	NA NA	13.	NA NA	NA NA	NA NA	25.
Theilium	13. U	NA NA	13. U	NA NA	NA.	NA NA	13. U
Zinc	17125. J	NA NA	20625. J	NA NA	NA NA	NA NA	27000. J
EP-TOXICITY METALS (in mg/l)	17123. 0	140	20025. 0	144	13/1	195	27000. 0
EPTOX Arsenic	0.33 U	NA	0.33 U	NA	NA	NA	0.33 U
EPTOX Barrium	0.5 U	NA NA	0.5 U	NA NA	NA NA	NA NA	0.5 U
EPTOX Cedmium	0.003 U	NA NA	0.003 U	NA NA	NA.	NA NA	0.013
EPTOX Chromium	0.033 U	NA NA	0.033 U	NA NA	NA NA	NA NA	0.033 U
EPTOX Lead	0.033 0	NA NA	0.03	NA NA	NA.	NA NA	0.47
EPTOX Copper	0.017 U	NA NA	0.017 U	NA NA	NA NA	NA NA	55
EPTOX Zinc	0.50	. NA	1.6	NA NA	NA NA	NA NA	0.45
EPTOX Mercury (in µg/l)	0.5 U	NA	0.5 U	NA NA	NA NA	NA NA	0.5 U
pH	5.2	NA NA	6.2	NA NA	NA NA	NA NA	6.0
VOLATILE ORGANIC COMPOUNDS (in		inu.	0.2	100	13/1	1971	0.0
Benzene	NA	NA.	NA	NA	. NA	NA	NA
Toluene	NA NA	NA NA	NA NA	NA NA	NA.	NA NA	NA NA
Ethylbenzne	NA NA	NA NA	NA NA	NA NA	NA NA	NA NA	NA.
Total Xylenes	NA NA	NA NA	NA NA	NA NA	NA NA	NA NA	NA NA
SEMIVOLATILE DREAMIC COMPOUN		191	161	1971		101	100
Acenzpthylene	0.30 U	0.30 U ·	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
N-nitrosodiphenyamine	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Phenanthrene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Di-n-butyl phthelate	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 N
Fluoranthene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Pyrane	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Benzo(a)anthracene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Bis(2-ethylhexyl)phthalate	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 N
Chrysene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.34
Benzo(b)fluoranthene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.41
Benzo(k)fluoranthene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Benzo(a)pyrene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Indeno(1,2,3-cd)pyrene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Benzo(ghi)perylene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
a-BHC	NA NA	NA NA	NA NA	NA .	NA	NA .	NA
Retene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Dimethylanaline	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
1-methylphenanthrene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
n,n 2-methylphenanthrene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
1-methylpyrene	0.30 U	0.30 U	0.30 U	0.40 U	0.30 U	0.40 U	0.30 U
Total Petroleum Hydrocarbons	31 U	31 U	32 U	43 U	42 U	24 U	570
TOTAL FOR STORING TOTAL SCRIPTION	J1 V	31 0	<b>5. 5</b>	10 0	,,,	*	• • •

HC STATION NO:	8-36	D-36	B-36	8-37	B-37	8-
HC SAMPLE NUMBER:	8-2	8-3	8-4	8-1	8-2	•
SAMPLE DEPTH:	125-14	25.5 -27	28 - 29.5	0 - 5	105 - 12	20.5 -
MATRIX:	SLAGFILL	SLAG FILL	NATIVE SAND	SLAG FILL	<b>SLAG FILL</b>	NATIVE 8A
6W REGIME:	PLANT	PLANT	PLANT	PLANT	PLANT	PLA
TOTAL METALS (in mg/kg DB)						
Antimony	NA NA	NA	NA	3313. J	NA	
Arsenic	NA	NA	NA NA	24950.	NA	2
Barium	NA	NA	NA	<b>350</b> .	NA	
Cadmium	NA	NA	NA	<b>25</b> .	NA	
Chromium	NA	NA	NĄ	120.	NA	1
Copper	NA	NA	NA	10975.	NA	3
Lead	NA	NA .	NA	9175.	NA	2
Mercury	NA '	NA	NA	112	NA	O
Nickel	NA	NA	NA	75. J	NA	
Selenium	NA	NA	NA	63,	NA.	
Silver	NA	NA	NA	114.	NA	
Theilium	NA	NA	NA	13. U	NA	
Zinc	NA	NA	NA	14000. J	NA	12
EP-TOXICITY METALS (in mg/l)						
EPTOX Arsenic	NA	NA	NA ,	0.33 U	NA	0
EPTOX Barium	NA	NA	NA	0.5 U	NA	
EPTOX Cadmium	NA	NA	NA	0.005	NA	O.
EPTOX Chromium	NA	NA	NA	0.033 U	NA	0.0
EPTOX Lend	NA NA	NA	NA	0.02 U	NA	Q
EPTOX Copper	NA	NA	NA	1.3	NA	Q
EPTOX Zinc	NA	NA	NA	0.70	NA	0
EPTOX Mercury (in µg/l)	NA	NA	NA .	0.5 U	NA	
рН	NA NA	NA	NA	5.2	NA	
YOLATILE ORGANIC COMPOUNDS (in				-4		
Banzene	20 U	, NA	NA.	NA.	NA	
Toluene	20 U	NA	NA	NA.	NA	
Ethylbenzne	55	NA	NA	NA	NA	
Total Xylenes	110	NA	NA	NA	NA	
SEMIYOLATILE ORGANIC COMPOUN						
Acenapthylene	Q40 U	0.40 U	Q40 U	0.40 U	0.34	Ç
N-nitrosodiphenyamine	0.40 U	0.40 U	0.40 U	0.40 U	051	Q
Phenanthrene	0.60	0.40 U	0.40 U	0.40 U	0.68	0
Di-n-butyl phthelate	0.40 N	0.40 N	0.40 N	0.40 N	0.30 N	Ç
Fluorenthene	0.55	0.40 U	0.40 U	0.40 U	0.30 U	Q
Pyrene	200	0.40 U	0.40 U	0.40 U	0.30 U	Ç
Benzo(a)anthracene	0.40 U	0.40 U	0.40 U	0.40 U	0.30 U	0
Bis(2-ethylhexyl)phthalate	0.40 U	0.40 N	0.40 N 0.40 U	0.40 U 0.40 U	0.30 U 0.30 U	
Chrysene Benzo(b)fluoranthene	1.28	0.40 U				
Benzo(k)fluoranthene	0.40 U 0.40 U	0.40 U 0.40 U	0.40 U 0.40 U	0.40 U 0.40 U	0.30 ม 0.30 บ	Q Q
Benzo(a)pyrene	0.40	0.40 U	0.40 U	0.40 U	0.30 U	
Indeno(1,2,3-cd)pyrene	040 U	0.40 U	0.40 U	0.40 U	0.30 U	Č
Benzo(ghi)perylene	0.40 U	0.40 U	0.40 U	0.40 U	0.30 U	
a-BHC	0.022	NA	NA	NA	0.30 G NA	
Retene	0.022 0.40 U	0.40 U	0.40 U	0.40 U	0.30 U	O
Dimethylanaline	0.40 U	0.40 U	. 0.40 U	0.40 U	812.	
1-methylphenanthrene	0.62	0.40 U	0.40 U	0.40 U	0.30 U	Č
n,n 2-methylphenanthrene	1.17	0.40 U	0.40 U	0.40 U	0.30 U	Q
-	250	0.40 0	0.40 U	0.40 11	- 0.30 11	
Total recroleum nyurocarbum	5700	8,				

Continued HW-2A B-2C2 B-2C2 B-3A HC STATION NO: B-IA MW-1A2 HW-2A 6-2 HC SAMPLE NUMBER: 8-1 6-1 6-1 S-2 8-1 8-4 20 - 21.533 - 34.540.5 - 42 0-10 SAMPLE DEPTH: 10-11 0 - 1015 - 20 NATIVE SAND NATIVE SAND SLAG FILL SLAG FILL SLAG FILL SLAG FILL SLAG FILL MATRIX: PLANT PLANT PLANT PLANT PLANT PLANT **6W REGIME:** PLANT TOTAL METALS (in mg/kg D6) NA 228. J 13. R 13. R NA NA 13. R Antimony NA 4025. 975. 1025. NA NA 53. Arsenic 450. · 700. 700. 725. NA NA NA Barrium 7.5 5.8 5.3 NA NA 0.50 U Cadmium NA 75. 125. Chromium NA 108. NA NA 120. 3350. 3250. 2750. NA NA 3700. Соррег NA 205. Lead NA 3000. 203. NA NA 198. 0.075 NA Mercury NA 0.07 0.03 NA 0.02 83. 35. 43. NA NA 63. Nickel NA NA 1.0 U 1.0 U 1.2 NA NA 1.4 Selenium 5.3 5.8 NA NA 5.3 Silver NA 9.5 16. 17. 18. NA NA 16. Thallium NA NA 20250. 5000. 6000. NA NA 7000. Zinc EP-TOXICITY METALS (in max)) 0.33 U 1.1 NA NA 0.33 U **EPTOX Arsenic** NA 1.1 EPTOX Barium 0.50 U NA NA 0.50 U 0.50 U NA 0.50 U **EPTOX Codmium** NA 0.020 U 0.020 U 0.020 U NA NA 0.020 U 0.033 U 0.033 U NA NA 0.033 U **EPTOX Chromium** NA 0.033 U 0.020 U NA NA NA 0.020 U 0.020 U 0.022 **EPTOX Lead EPTOX Copper** NA 1.6 1.2 2.0 NA NA 3.3 NA NA 0.58 NA 4.0 3.0 2.0 **EPTOX Zinc** NA 0.5 U 05 U 0.5 U NA NA 0.5 U EPTOX Mercury (in µg/l) NA 4.82 6.50 6.38 NA NA 5.53 VOLATILE ORGANIC COMPOUNDS (in ug/kg DB) NA NA NA NA NA Benzene NA Toluene NA NA NA NA NA NA NA NA NA NA NA NA NA NA Ethylbenzne NA NA NA NA NA NA NA Total Xylenes SEMIYOLATILE ORGANIC COMPOUNDS (in ma/kg D6) 0.30 N 0.40 N 0.40 N NA NA Acenapthylene 0.30 N NA 0.30 N 0.40 N 0.40 N NA 0.30 N NA NA N-mitrosodiphenyamine 0.30 N NA NA 0.30 N 0.40 N 0.40 N NA Phenanthrene NA 0.30 N 0.40 N 0.40 N NA Di-n-butyl phthelate 0.30 N NA 0.30 N NA NA NA 0.40 N 0.40 N Fluoranthene 0.30 N 0.30 N 0.40 N 0.40 N NA 0.30 N NA NA Pyrene Benzo(a)anthracene 0.30 N NA NA 0.30 N 0.40 N 0.40 N NA NA 0.30 N 0.40 N 0.69 N NA Bis(2-ethylhexyl)phthalate 1.02 J NA 030 N 0.40 N 0.40 N NA 0.30 N NA NA Chrysene 0.30 N 0.40 N 0.40 N NA Benzo(b)fluoranthene 0.30 N NA NA 0.30 N 0.40 N NA 0.40 N Benzo(k)fluoranthene 0.30 N NA NA 0.30 N 0.40 N 0.40 N NA 0.30 N NA NA Benzo(a)pyrene NA Indeno(1,2,3-cd)pyrene 0.30 N NA NA 0.30 N 0.40 N 0.40 N 0.30 N NA NA 0.30 N 0.40 N 0.40 N NA Benzo(ghi)perylene NA NA NA NA a-BHC NA NA NA 0.40 N 0.40 N NA Retene 0.30 N NA NA 0.30 N 0.40 N 0.40 N NA 0.30 N 0.30 N NA NA Dimethylanaline 0.40 N 0.40 N NA NA NA 030 N 0.30 N 1-methylphenanthrene NA 0.30 N NA NA 0.30 N 0.40 N 0.40 N n,n 2-methylphenanthrene 0.40 N 0.40 N NA 0.30 N 0.30 N NA NA 1-methylpyrene 99 N NA 41 N NA NA 43 N

74 N

Total Petroleum Hydrocarbons

Continued	,						
HE STATION NO:	8-3A	HW-4	17W-4	HW-5	HW-5	HW-5	HW-6
HC SAMPLE NUMBER:	8-3	8-6	8-13	8-4	8-19	8-25	8-6
SAMPLE DEPTH:	29.5 - 32.5	13-14.5	30.5 - 31.5	8 - 9.5	45.5 - 46.5	61 - 62	18 - 18.5
MATRIX:	SLAGFILL	NATIVE SAND	NATIVE GRAYEL	NATIVE SAND	NATIVE SOIL	NATIVE SAND	NATIVE BILT
6W REGIME:	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT	PLANT
TOTAL METALS (in mg/kg DB)	<del></del>						· · · · · · · · · · · · · · · · · · ·
Antimony	NA	25. J	NA	13. J	13. R	13. R	13. R
Arsenic	NA	98.	NA	11.	40.	10	<b>13</b> .
Barium	NA.	<b>53</b> .	NA	66.	<b>30</b> .	38.	76.
Cadmium	NA	0.58	NA	050 U	0.50 U	0.50 U	0.58
Chromium	NA	43.	NA	90.	<b>33</b> .	45.	70.
Copper	NA.	600.	NA	<b>50</b> .	22	16.	228.
Lead	NA	<b>375</b> .	NA	17.	11.	9.3	25.
Mercury	NA	0.305	NA	0.11	0.075	0.04	0.155
Nickel	NA 1	73.	NA	90.	22	38.	115.
Selenium	NA	1.8	NA	1.0 U	1.0 U	1:0 U	1.0 U
Silver	NA	7.	NA	25 U	25 U	25 U	25 U
Thallium	NA	13. U	NA	13. U	13. U	13. U	13. U
Zinc	NA	118.	NA	<b>85</b> .	43.	48.	86.
EP-TOXICITY METALS (in mg/1)							
EPTOX Arsenic	0.33 U	0.33 U	NA.	0.33 U	0.33 U	0.33 U	0.33 U
EPTOX Barium	0.50 U	0.50 U	NA	0.50 U	0.50 U	Q.50 U	0.50 U
EPTOX Cadmium	0.020 U	0.020 U	NA	0.020 U	0.020 U	0.020 U	0.020 U
EPTOX Chromium	0.033 U	0.033 U	NA	0.033 U	0.033 U	0.033 U	. 0.033 U
EPTOX Lead	0.022	0.020 U	NA.	0.020 U	0.020 U	0.020 U	0.020 U
EPTOX Copper	3.3	0.023	NA.	0.023	0.027	0.017 U	0.023
EPTOX Zinc	0.56	0.017	NA.	0.017 U	0.028	0.017 U	0.05\$
EPTOX Mercury (in µg/l)	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U
pH	5.53	7.20	NA	7.93	5.20	4.82	6.38
<b>VOLATILE ORGANIC COMPOUNDS (I</b>	n µg/kg DB)						
Benzene	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA
Ethylbenzne	NA	NA	NA	NA	NA	NA	NA
Total Xylenes	NA	NA	NA	NA	NA	NA	N
SEMIYOLATILE ORGANIC COMPOUN	DS (in mg/kg DS)						
Acenapthylene	0.30 N	NA	0.40 N	NA	NA	NA	NA
N-nitrosodiphenyamine	0.30 N	NA	0.40 N	NA	NA	NA	NA
Phenanthrene	0.30 N	NA	0.40 N	NA	NA	NA	NA
Di-n-butyl phthalate	0.30 N	NA	0.40 N	NA	NA	NA	NA
Fluoranthene ;	0.30 N	NA	0.40 N	NA	NA	NA	NA
Pyrene	0.44 J	NA	0.40 N	NA	NA	NA	NA
Benzo(a)anthracene	0.30 N	NA	0.40 N	NA	· NA	NA	NA
Bis(2-ethylhexyl)phthalate	0.55 J	NA	0.40 N	NA	NA	NA	NA
Chrysene	0.30 N	NA	0.40 N	NA	NA	· NA	NA
Benzo(b)fluoranthene	0.30 N	NA	0.40 N	NA	NA	NA	NA
Benzo(k)fluoranthene	0.30 N	NA	0.40 N	, NA	NA	, NA	NA
Benzo(a)pyrene	0.30 N	NA	0.40 N	NA 111	NA 	NA A	NA
Indeno(1,2,3-cd)pyrene	0.30 N	NA	0.40 N	NA	NA 111	NA A	NA
Benzo(ghi)perylene	0.30 N	NA	0.40 N	NA	NA .	NA	NA
a-BHC	NA O TO TI	NA 411	NA 242 H	NA	NA ***	NA NA	NA
Retene	0.30 N	NA ***	0.40 N	NA 111	NA ***	NA NA	NA 111
Dimethylanaline	0.30 N	NA NA	0.40 N	NA Ala	NA NA	NA NA	NA NA
1-methylphenanthrene	0.30 N	NA Ala	0.40 N	NA NA	NA NA	NA NA	NA 411
n,n 2-methylphenanthrene	0.30 N 0,≖∩ N	NA Na	0.40 N	NA NA	NA NA	NA NA	NA NA
1-mathuloyrene,			040 N	NA NA	NA 11A	NA NA	NA.
~ Total rear oleuminy arocerbaia ~	19.00	N	4.7,4	NA	- N -	N	<b>W</b> :-

Continued HC STATION NO: MW-6 8-7 MW-8 HW-8 MW-8 MW-8 HW-8 HC SAMPLE NUMBER: 8-12 8-6 8-2 8-4 8-6 8-7 8-8 **SAMPLE DEPTH:** 28.5 - 3013.5 - 1525 - 4 7-85 12-125 145-15 17 - 18.5NATIVE SILT **MATRIX**: **NATIVE SILT SLAG FILL SLAG FILL** SLAG FILL SLAG FUL NATIVE GRAYEL PLANT **6W REGIME:** PLANT PLANT PLANT PLANT PLANT PLANT TOTAL METALS (in mg/kg D6) NA 13. R NA 13. R NA NA Antimony NA 10. 750. Arsenic NA NA NA NA NA Bartum NA 80. NA 425. NA NA NA NA 050 U NA 6.8 Cadmium NA NA NA NA 90. NA 90. NA NA Chromium NA NA 46. NA 1650. NA Copper NA NA 9000. NA 20. NA NA NA NA Lesd NA 0.06 0.04 Mercury NA NA NA NA 85. Nickel NA NA 45. NA NA NA NA 1.0 U NA Selenium 1.7 NA NA NA Silver NA 25 U NA 15 NA NA NA Thallium NA NA 13. U 17. NA NA NA Zinc NA 93. NA 6000. NA NA NA EP-TOXICITY METALS (in mg/1) **EPTOX Arsenic** 0.33 U 0.33 U NA NA NA NA NA **EPTOX Barium** NA 0.50 U NA 0.50 U NA NA NA **EPTOX Codmium** NA 0.020 U NA 0.020 U NA NA NA 0.033 U **EPTOX Chromium** NA NA 0.033 U NA NA NA NA NA **EPTOX Lead** 0.020 U NA 0.020 U NA NA **EPTOX Copper** NA 0.082 NA 0.093 NA NA NA **EPTOX Zinc** NA 0.035 NA 0.042 NA NA NA NA 0.5 U NA 0.5 U NA NA EPTOX Mercury (in µg/1) NA NA 6.05 NA 6.66 NA NA NA VOLATILE ORGANIC COMPOUNDS (in ug/kg DB) Benzene NA NA NA NA NA NA Toluene NA NA NA NA NA NA NA Ethylbenzne NA NA NA NA NA NA NA NA NA NA NA NA NA NA Total Xylenes SEMIYOLATILE ORGANIC COMPOUNDS (in mg/kg D6) NA 0.40 N NA 0.40 N NA 0.40 N Acenapthylene 0.40 N NA 0.40 N NA 0.40 N NA 0.40 N N-nitrosodiphenyamine 0.40 N Phenanthrene 0.40 N NA 0.40 N NA 0.40 N NA 0.40 N 0.40 N NA 0.40 N NA 0.40 N NA 0.40 N Di-n-butyl phthalste 0.40 N Fluoranthene 0.40 N NA 0.65 J NA 0.40 N NA 1.05 J NA 0.40 N NA 0.40 N Pyrene 0.40 N NA 0.40 N NA 0.68 J NA 0.40 N NA Benzo(a)anthracene 0.40 N NA Bis(2-ethylhexyl)phthalate 0.40 N NA 0.58 J NA 0.41 N 0.40 N NA 0.40 N Chrysene 0.40 N NA 123 J NA 0.40 N NA 0.40 N 0.40 N NA 1.19 J NA 0.40 N Benzo(b)fluoranthene Benzo(k)fluoranthene 0.40 N NA 0.54 J NA 0.40 N NA 0.40 N NA 0.68 J NA 0.40 N NA 0.40 N 0.40 N Benzo(s)pyrene NA 0.40 N NA 0.76 J NA 0.40 N Indeno(1,2,3-cd)pyrene 0.40 N 0.40 N 0.40 N NA 0.94 J NA 0.40 N NA Benzo(ghi)perylene NA NA NA NA NA NA a-BHC NA 0.40 N NA NA 0.40 N NA 0.40 N 0.40 N Retene NA 0.40 N NA 0.40 N NA 0.40 N Dimethylanaline 0.40 N 0.40 N NA 0.40 N NA 1-methylphenanthrene 0.40 N NA 0.40 N NA 0.40 N NA 0.40 N n,n 2-methylphenanthrene 0.40 N NA 0.40 N NA 0.40 N NA 0.40 N NA 0.40 N 0.40 N 1-methylpyrene NA 140 N NA 1400 J NA 1600 J **Total Petroleum Hydrocarbons** 39 N

. Continued			,			
HC STATION NO:	HW-8	HW-9	MW-9	B-10	HW-11	HV-12
HC SAMPLE NUMBER:	8-10	8-4	8-13	8-19	8-3	8-12
SAMPLE DEPTH:	22 - 23.5	10-11.5	<b>325 - 34</b>	45.5 - 47	5.5 - 7	28.5 - 30
HATRIX:		<b>SLAG FILL</b>	NATIVE SILT	NATIVE SILT	native sand	Granular fill
6¥ REGIME:	PLANT	PLANT	PLANT	PLANT	STACK	PLANT
TOTAL METALS (in mg/kg DB)	•		,			
Antimony	NA	NA	13. R	13. R	13. R	13. R
Arsenic	NA	NA	25	9.5	118.	75.
Barium	NA	NA	85.	36.	80.	<b>53</b> .
Cadmium	NA NA	NA	0.5 U	05 U	3.8	3.3
Chromium	NA NA	NA	103.	110.	76.	68.
Copper	NA	NA	<b>56</b> .	63.	1 <b>6</b> 0.	<b>158</b> .
Lead	NA NA	NA	19.	20.	70.	100.
Mercury	, NA	NA	0.07	0.105	8.	0.29
Nickel	NA NA	NA	96.	103.	73.	<b>6</b> 0.
Selenium	NA	NA	1.0 U	1.1	1.0 U	1.0 U
Silver	NA	NA	25 U	25 U	25 U	25 U
Thallium	N4	NA	13. U	13. U	13. U	13. U
Zinc	NA	NA	110.	110.	<b>190</b> .	140.
EP-TOXICITY METALS (in mg/l)						
EPTOX Arsenic	NA	NA	0.33 U	0.33 U	0.33 U	0.33 U
EPTOX Barium	NA	NA.	Q50 U	0.50 U	0.50 U	Q50 U
EPTOX Cadmium	NA	NA	0.020 U	0.020 U	0.020 U	0.020 U
EPTOX Chromium	NA	NA	0.033 U	0.033 U	0.033 U	0.033 U
EPTOX Lead	NA	NA	0.020 U	0.020 U	0.020 U	0.020 U
EPTOX Copper	NA	NA	0.028	0.017 U	0.017 U	0.017 U
EPTOX Zinc	NA	NA	0.026	0.017 U	0.026 U	0.017 U
EPTOX Mercury (in µg/l)	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U
pH	NA	NA	8.72	8.16	6.81	5.17
<b>YOLATILE ORGANIC COMPOUNDS</b>	(in µg/kg 06)					
Benzene	NA.	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA
Ethylbenzne	NA	NA	NA.	NA	NA	NA
Total Xylenes	NA	NA	NA	NA	NA	NA
SEMIYOLATILE ORGANIC COMPOU	INDS (in mg/kg DB)					
Acenapthylene	0.40 N	0.40 N	NA	NA	NA	NA
N-nitrosodiphenyamine	0.40 N	0.40 N	NA	NA	NA	NA
Phenanthrene	0.40 N	0.40 N	NA	NA	NA	NA
Di-m-butyl phthalate	0.40 N	0.40 N	NA	NA	NA	NA
Fluoranthene	0.40 N	0.40 N	NA	NA	NA	NA
Pyrane	0.40 N	0.40 N	NA	NA	NA	NA
Benzo(a)anthracene	0.40 N	0.40 N	NA	NA	NA	, NA
Bis(2-ethylhexyl)phthalate	0.40 N	0.76 J	NA	NA 	NA	NA
Chrysene	0.40 N	0.40 N	NA 111	NA	NA .	NA NA
Benzo(b)fluoranthene	0.40 N	0.40 N	NA	NA	NA	NA ***
Benzo(k)fluorenthene	0.40 N	0.40 N	NA NA	NA ***	NA 111	NA
Benzo(a)pyrene	0.40 N	0.40 N	NA A	NA NA	NA NA	NA 111
Indenol 1,2,3-cd)pyrene	0.40 N	0.40 N	NA NA	NA 11	NA NA	NA NA
Benzo(ghi)perylene	0.40 N	0.40 N	NA NA	NA NA	NA NA	NA NA
a-BHC	NA 0.40 N	NA 0.40 N	NA NA	. NA NA	NA NA	NA NA
Retene Dimethylanaline	0.40 N	0.40 N	NA NA	NA NA	NA NA	NA NA
i-methylphenanthrene	0.40 N	0.40 N	NA NA	NA NA	NA NA	NA NA
n,n 2-methylphenanthrene	0.40 N	0.40 N	NA NA	NA NA	NA NA	NA NA
i-m-i-yrene	0.40 81	0.40 M	NA .	NA NA	, NA	, NA
Total repoleum nyel gcarbus	•	1200	M	N		
TOTAL FOR CIDENTITY OF THE DUIS	N OC.	120 0	IVI	iwi and	194	· · · · · · · · · · · · · · · · · · ·

APPENDIX K

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GROUNDWATER

## **Groundwater Results**

Groundwater results for Phase I and Phase II samples are summarized in the following tables. Analytes which were not detected in any groundwater samples were not included in these tables. Laboratory data packages are available upon request.

Data qualifiers:

NA = not analyzed

Summary of Chemical Analysis of Groundwater HC STATION NO: HW-1A2 (LOW) HW-1A2 (MED) MW-1A2 (HIGH) MW-IB (LOW) HW-IB (MED) PTW-(B (HIGH) SCREENED AQUIFER FILL FILL FILL FILL FILL FILL **GW REGIME:** PLANT PLANT **PLANT** PLANT PLANT PLANT TOTAL METALS (in µg/1) Antimony (D) 80. U 80. U 80. U 125. 113. 125. Antimony (T) 175 80. U 163. 175. 168. 125. Arsenic (D) 8410 9250. 7540. 400. 475. 400. Arsenic (T) 13600. 13400. 10200. 1030. 1450. 413. Barium (D) 110. U 110. U 110. U 110. U 110. U 110. U 110. U Barium (T) 110. 110. U 110. U 110. U 110. U 1.0 U Cadmium (D) 1.0 U 1.0 U 63. 76. 80. Cadmium (T) 123. 73. 194. 63. 84. 81. Chromium (D) 30. U 30. U 30. U 30. U 30. U 30. U Chromium (T) 30. U 30. U 30. U 30. U 30. U 30. U Copper(D) 9. 14. 8. 3340. 4530. 4740. Copper(1) 1680. 751. 1930. 3530. 4960. 4780. Nickel (D) 30. 30. U 30 63. 50. 50. Nickel (T) 30. 30. 30. U 63. 50. 50. Selenium (D) 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U 5.0 Selenium (T) 5.0 U 5.0 U 5.0 U 9.0 15. 6.0 Silver (D) 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U Silver (T) 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 80 U Thallium (D) 100. U 100. U 100. U 100. U 100. U 100. U Thallium (T) 100. U 100. U 100. U 100. U 100. U 100. U Zinc (D) 51. 38. 29. 8190. 7130. 7050. Zinc(T) 4000. 2090. 4230. 8250. 7300. 7030. Lead(D) 25. N 50. N 50. N 50. N 50. N 25. N Lead(T) 313. 125. 338. 175. 88. 25. N Mercury (T) NA NA NA NA NA NA Mercury (D) NA NA NA NA NA NA 41500. Iron 40400. 33800. 7130. 3500. 24300. 1060. Manganese 1130. 1050. 1160. 1100. 1050. Magnesium (in mg/l) 290. 280. 300. 310. 310. 330. MISCELLANEOUS INORGANICS (in mg/l) 2295. Sodium 2203. 2440. 2650. 2670. 2555. Potassium 110. 108. 115. 140. 138. 138. 150. Calcium 140 144. 154. 144. 145. Chloride 4300. 4400. 4900. 5000. 4700. 4200. Suifate 1050. 1050. 1050. 1050. 1100. 1050. Sulfide 2.9 1.9 0.5 U 0.5 U 0.5 U 1.8 Bicarbonate 122. 130. 134. 10. 36. 51. Alkalinity 122. 130. 134. 10. 38. 51. YOLATILE ORGANIC COMPOUNDS (in µg/i) 5 U NA 5 U NA Benzene NA NA 5 U NA Toluene NA NA 5 U NA 5 U Ethylbenzene NA NA S U NA NA NA NA NA NA NA **Xylenes** NA 5 U NA 5 U NA NA Chloroform NA SEMIYOLATILE DREANIC COMPOUNDS (in µg/I) Dimethylaniline 20. U NA NA 40. U NA NA NA NA Total Pet. Hydrocarbons(in mg/l) NA NA NA NA 2.5 3.0 2.4 2.0 1.7 1.4 Total Organic Carbon (in mg/l)

Table Continued HW-2A (MED) HW-2B (HIGH) MW-28 (LOW) MV-28 (MED) HC STATION NO: MW-2A (LOW) MW-2A (HIGH) SCREENED AQUIFER FILL FILL FILL FILL FILL **6W REGIME:** PLANT PLANT PLANT **PLANT PLANT** PLANT TOTAL HETALS (in µg/1) 80. U Antimony (D) 80. U 80. U 80. U 80. U Antimony (T) 80. U 80. U 80. U 80. U 80. U Arsenic (D) 30600. 29400. 21 100. 2510. 13300. 7500. Arsenic (T) 30600. 30000. 2650. 14800. 21600. Barium (D) 110. U 110. U 110. U 110. U 110. U Barium (1) 110. U 110. U 110. U 110. U 110. 25. Codmium (D) 1.0 U **50**. 1.0 5.0 Cadmium (T) 51. 25. 3.0 1.0 4.0 Chromium (D) 30. U 30. U 30. U 30. U 30. U Chromium (T) 30. U 30. U 30. U 30. U 30. U Copper (D) 18. 20. 8. 598 864. Copper(T) 81. 36. 11. 566. 914.

FILL

80. U

80. U

7540.

110. U

110. U

36.

36.

30. U

30. U

726.

Copper (u)	10.	20.	Q.	J90.	OU-1.	120.
Copper (T)	81.	36.	11.	<b>566</b> .	914.	805.
Nickel (D)	36.	<b>75</b> .	<b>75</b> .	113.	113.	88.
Nickel (T)	<b>50</b> .	75.	75.	113.	113.	88.
Selenium (0)	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Selenium (T)	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Silver (D)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Silver(T)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Thallium (D)	100. U	100. U	100. U	100. U	100. U	100. U
Thallium (T)	100. U	100. U	100. U	100. U	100. U	100. U
Zinc (0)	838.	<b>950</b> .	1 <b>59</b> 0.	2690.	2500.	2290.
Zinc (T)	963.	1000.	1550.	2740.	2510.	2310.
Lend(0)	25. N	<b>25</b> .	50. N	5.0 N	25. N	25. N
Lead(T)	25. N	<b>50</b> .	50. N	5.0 N	50. U	25. N
Hercury (T)	NA	NA	NA	NA	NA	NA
Mercury (D)	NA	NA	NA	NA	NA	NA
iron	7880.	10600.	12500.	113.	3800.	900.
Manganese	<b>3380</b> .	<b>3210</b> .	3550.	1790.	2760.	1750.
Magnesium (in mg/l)	<b>290</b> .	<b>350</b> .	<b>420</b> .	<b>240</b> .	150.	210.
MISCELLANEOUS INORGANICS (in m	g/1)					
Sodium	2306.	2750.	3638.	1753.	1106.	1520.
Potessium	138	138.	173.	90.	<b>60</b> .	80.
Calcium	232.	230.	280.	175.	150.	165.
Chloride	4250.	5000.	6900.	3400.	1800.	2700.
Sulfate	1400.	840.	<b>650</b> .	1000.	770.	<b>750</b> .
Sul fide	1.5	0.69	1.8	0.5 U	0.87	2.2
Bicarbonate	130.	<b>79</b> .	60.	16.	41.	43.
Alkalinity	130.	79.	60.	16.	41.	43.
VOLATILE ORGANIC COMPOUNDS (in	µg/l)	•				
Benzene	NA	NA	NA	NA .	NA	NA
Toluene	NA	NA.	NA NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA
Xylenes	NA	NA	NA	NA	NA .	NA
Chloroform	NA	NA	NA	NA	NA	NA
SEMIYOLATILE ORGANIC COMPOUND	\$ (in µg/i)	•				
Dimethylaniline	NA	NA	NA.	NA	NA	NA
Total Pet Hidrocethood(inmeth	NA.	NA .	NA.	NA .	NA	NA
- rotal Gryanic Carbon sin mg/l)	0.9	0.8	0.7	1.0	hand an	وبيست

Continued Table HC STATION NO: MW-3A2 (LOW) HW-3A2 (MED) MW-3A2 (HIGH) HW-3B (HIGH) MW-4 MW-5 MW-6 SCREENED AQUIFER FILL FILL FILL FILL FILL FILL FILL **GW REGIME:** PLANT PLANT PLANT PLANT **PLANT** PLANT PLANT TOTAL METALS (in µg/I) 80. U 80. U 80. U 80 U ao u Antimony (D) 80. U 80. U Antimony (T) 80. U 80. U 80. U 80. U 80 U 80. U 80 U Arsenic (D) 54. 51. 26. :33. 6 U 6 U 41. 9380. Arsenic (T) 10700. 2440. 64. 69. 50 6.0 U Barium (D) 110. U 110. U 110 U 110. U 110. U 110. U 110 U Barium (7) 440. 220. 330. 110. U 330. 660 110 U Cadmium (D) 4.0 4.0 4.0 1.0 U 1.0 U 10 U 1.0 U Cadmium (T) 4.0 5.0 4.0 1.0 U 1.0 U 1.0 U 1.0 U Chromium (D) 30. U 30. U 30. U 30. U 30. U 30 U 30 U Chromium (T) **30**. 30. 30. 30. U 138. 475 30 U Copper (D) 258. 286. 226. 354. 263. 13 8 Copper(T) 7240. 10700. 4930. 606. 3690. 431 21 Nickel (D) 125. 125. 88. 88. 830. 30 U 30 U Nickel (T) 225. 288 163. 88. 1300. 288 30 U Selenium (D) 163 188. 175. 150. 5.0 U 5.0 U 5.0 U Selenium (T) 188. 175. 175. 188. 5.0 U 5.0 U 5.0 U Silver (D) 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U Silver (T) 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U Thallium (D) 100. U 100. U 100. U 100. U 100. U 100 U 100 U Thallium (T) 100. U 100. U 100. U 100. U 100. U 100 U 100 U Zinc (D) 250. 275. 250. 275. 26. 14 8.0 Zinc(T) 1350. 1880. 1750. 500. 250. 563 11 Lead(D) 50. U 25. N 50. N 25. N 25. U 5.0 U 5.0 U Lead(T) 100 125. 75. 25. 63. 100. 5.0 U NA NA 0.5 U 05 U 0.5 U Mercury (T) NA NA NA Mercury (D) NA NA NA NA NA NA tron 62000. 146000. 45600. 3130. 113000. 258000 600. Manganèse 225. 388. 238. 63. 1390. 1290. 375. Magnesium (in mg/l) 850. 800. 790. 840. 21. 14. 16. MISCELLANEOUS INORGANICS (in ma/l) Sodium 7350. 7175. 7300. 6925. 40. 36. 31. Potassium 345. 338. 343. 325. 8.1 14. 5.4 Calcium 320. 310. 323. 310. 25. 18. 31. Chloride 14000. 13000. 12 13500. 13500. 21. 16. Sulfate 1550. 2000. 96. **37**. 1450. 1400. 100. 05 U 0.5 U Sulfide 0.5 U 0.5 U 0.5 U 0.5 U 0.5 U **Bicarbonate** 50. 47. 51. 67. 130. 154. 41. 50. 47. 51. 67. 130. 154. Alkalinity 41. YOLATILE ORGANIC COMPOUNDS (in µg/l) Benzene 1 U NA NA NA NA NA NA Toluene 1 0 NA NA NA NA NA NA Ethylbenzene NA NA 1 U NA NA NA NA NA NA **Xylenes** NA NA ŇΑ 1 U NA NA Chloroform NA NA NA NA NA ŇÅ SEMIYOLATILE ORGANIC COMPOUNDS (in µg/I)

NA

NA

0.9

NA

NA

0.6

NA

NA

2.2

NA

NA

1.7

NA

NA

1.0

Dimethylaniline

Total Pet. Hydrocarbons(in mg/l)

Total Organic Carbon (in mg/l)

20. U

NA

1.3

NA

NA

1.1

HC STATION NO: SCREENED AQUIFER GW REGIME:	D-6 MW-6 DUPL PLANT	MW-8 FILL PLANT	MW-9 FILL PLANT	D-9 HW-9 DUPL PLANT	MV-12 FILL PLANT	MV-13 PT DEFIANCE PARKING LOT	8-14 COMM. SAND 4 PLANT
TOTAL METALS (in µg/l)				<del>,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,</del>		<del></del>	
Antimony (D)	80. U	80. U	80. U	80. U	80. U	80. U	80.
Antimony (T)	80. U	80. U	80. U	80. U	80. U	80. U	80.
Arsenic (D)	18.	15300.	<b>250</b> .	313.	1050.	10.	11.
Arsenic (T)	14.	19100.	963.	875.	1830.	<b>25</b> .	9.
Barium (D)	110. U	110. U	110. U	110.	110.	110. U	110.
Barium (1)	110. U	110. U	1000.	660.	1100.	110. U	110.
Cadmium (D)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0
Cadmium (T)	1.0 U	1.0 U	18.0	14.	6.0	1.0 U	1.0
Chromium (D)	30. U	30. U	30. U	30. U	30. U	30. U	30.
Chromium (T)	30. U	<b>30</b> .	750.	<b>\$25</b> .	1010.	38.	30.
Copper (D)	61.	23.	8. U	11.	8. U	8. U	10.
Copper (T)	83.	101.	1510.	1110.	16.	8. U	19.
Nickel (D)	30. U	30. U	30. U	30. U	30. U	30. U	<b>30</b> .
Nickel (T)	30. U	30. U	588.	463.	675.	30. U	<b>30</b> .
Selenium (D)	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0
Selenium (T)	5.0 U	5 <u>.</u> 0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0
Silver (D)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0
Silver (T)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0
Theilium (D)	100. U	100. U	100. U	100. U	100. U	100. U	100.
Thallium (T)	100. U	100. U	100. U	100. U	100. U	100. U	100.
Zinc (D)	8.0	13.	8.0	8.0	14.	9.0	8.0
Zinc (T)	29.	138.	2710.	2030.	1050.	<b>56</b> .	8.0
Lead(D)	5.0 U	25. N	5. U	5.0 U	25. U	5.0 U	5.0
Lead(T)	5.0 U	250.	600.	<b>500</b> .	150.	25.	5.0 5.0
	05 U	NA	0.5 U	2.9	0.7	0.5 U	NA NA
Mercury (T)	NA NA	NA NA	NA NA	0.5 U	NA NA	NA NA	NA NA
Mercury (D)	138.	19000.	389000	256000.	441000.	8000.	475.
Iron		2510.		4690.	8130.	213.	313.
Manganese Magnesium (in mg/l)	675. 21.	230.	6060. - 9.	8.	8 1 3 U. 1 B.	213. 16.	313. 10.
•		250.	• ••	<b>O</b> .	10.	10.	10.
MISCELLANEOUS INORGANICS (in m							
Sodium	<b>26</b> .	1693.	22.	18.	17.	15.	13.
Potassium	6.3	105.	15.	11.	12	4.7	1 4.3
Calcium	40.	220.	41.	22.	34.	13.	11.
Chloride	20.	2800	<b>9</b> .	. <b>7</b> .	75	8.	3.
Sulfate	77.	860.	6.5	<b>6</b> .	3. U	40.	<b>3</b> .
Sulfide	05 U	2.6	1.8	0.5 U	0.5 U	0.5 U	0.5
Bicarbonate	169.	205.	141.	<b>130</b> .	263.	113.	115.
Alkalinity	169.	<b>205</b> .	141.	130.	263.	113.	115.
YOLATILE ORGANIC COMPOUNDS (in	n µg/l)						
Benzene	NA	1 U	NA	NA	NA	NA	1
Toluene	NA	ΙU	NA	NA	NA.	NA.	1
Ethylbenzene	NA	1 U	NA	NA	NA	NA.	1
Xylenes ·	NA	1 U	NA	NA	NA	NA	1
Chlorotorm	NA	NA	NA	NA	NA	NA	NA
SEMIVOLATILE ORGANIC COMPOUNE	D\$ (in µg/l)	•					
Dimethylaniline	NA	20. U	NA	NA	NA	NA.	20.
Total Pot Hadrocarhandinmo	NA	. NA	NA	NA	NA	NA.	NA

Table Continued HC STATION NO: B-16 B-17 8-18 B-19 B-25 B-26 B-27 SCREENED AQUIFER FILL COMM. SAND 2 COMM. SAND 2 COMM. SAND 1 PT. DEFIANCE FILL GW REGIME: PLANT STACK AREA STACK AREA STACK AREA **PLANT PARKING LOT PARKING LOT** TOTAL METALS (in µg/1) Antimony (D) 80. U 80. U 80. U 80. U-80. U 80 U 80 U Antimony (T) 80. U 80. U 80. U 80. U 80. U 80 U 80. U Arsenic (D) 4680. 20. 45. 61. 76. 6. U 9. Arsenic (T) 5760. 70 54. 64. 76. Q 29. Barium (0) 110. U 110. U 110. U 110. U 110. U 110. U 110. U Barium (1) 110. U 110. U 220. 110. U 110. U 330. 440. Cadmium (D) 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U Cadmium (T) 3.0 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U 1.0 U Chromium (D) 30. U 30. U 30. U 30. U 30. U 30 U 30. U Chromium (T) 30. 30. 163. 30. U 30. 238. 40. Copper (D) 53. 13. 14. 8. U 8. U 8. U 25. Copper(1) 590. 118. 201. 8. U 11. 205. 291. Nickel (D) 30. U 30. U 30. U 30. U 30 U 30 U 30. U Nickel (T) 30. U 30. U 150. 30. U 30 U 163. 212. Selenium (0) 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U Selenium (T) 5.0 U 5.0 U 5.0 5.0 U 5.0 U 250.0 5.0 U Silver (D) 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U Silver (T) 8.0 U 9.0 8.0 U 8.0 U 8.0 U 8.0 U 8.0 U Thallium (D) 100. U 100. U 100. U 100. U 100. U 100. U 100. U Thallium (T) 100. U 100. U 100. U 100. U 100. U 100. U 100. U Zinc (D) 23. 8.0 U 6.0 9.0 9.0 18 11. Zinc(T) 568. 61. 168. 10. 24. 250. 338. Lead(D) 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U Lead(T) 88. 25. 38. 5.0 U 28. 38. **50**. Mercury (T) NA 0.5 U 05 U 0.5 U 0.5 U 0.5 U 0.5 U Mercury (D) NA NA NA NA NA NA NA 25600. 10600. 66300. iron 1880. 21600. 101000 204000. Manganese 1380. 275. 1260. 375. 301Q 1160 **3240** Magnesium (in mg/l) 29. 5. 10. 13. 13 24 21. MISCELLANEOUS INORGANICS (in mg/1) Sodium 170. 19. 8.6 16. 9.6 24. 49 Potassium 30. 5.7 7.1 4. 2.6 9. 16. Calcium 67. 15 22 14. 22 31. 30. Chloride 5. 175. 6.5 4.5 Ō. 6.5 30. Sulfate 83. 12 29. 90. 3. 56 58. Sulfide 0.5 U NA 0.51 05 U 05 U 0.5 U 051 Bicarbonate 470. 83. 93. 51. 136. 192 215. **Alkalinity** 470. 93. 93. 51. 136. 192. 215. YOLATILE ORGANIC COMPOUNDS (in µg/1) Benzene 5 U NA NA NA NA NA NA Toluene 5 U NA NA NA NA NA NA Ethylbenzene 5 U NA ÌΝΑ NA NA NA NA Xylenes NA NA NA NA NA NA NA Chloroform 5 U NA NA NA . NA NA NA SEMIYOLATILE ORGANIC COMPOUNDS (in µg/I) NA NA Dirnethylaniline 20. U NA NA NA NA

NA

0.9

NA

2.7

NA

5.7

NA

1.9

NA

1.8

Total Pet. Hydrocarbons(in mg/l)

Total Organic Carbon (in ma/l)

NA

3.4

NA

1.3

HC STATION NO: SCREENED AQUIFER	6-31 COMM. \$AND 2	6-32 COMM. SAND 2	B-33 (10/20) FILL	₿-33 (10/26) FILL	B-34 FILL	B-35 FILL	8-36 FILL
6W REGIME:	STACK AREA	STACK AREA	PLANT	PLANT	PLANT	PLANT	PLANT
TOTAL HETALS (in µg/l)							
Antimony (D)	. 80. U	80. U	80. U	NA	80. U	80. U	80.
Antimony (T)	80. U	80. U	8Q. U	, <b>N</b> A	80. U	80. U	88.
Arsenic (D)	39.	30.	31.	NA	15.	<b>288</b> .	90.
Arsenic (T)	39. U	<b>50</b> .	175.	NA	1060.	<b>300</b> .	2340.
Barium (0)	110. U	110. U	110. U	NA.	110. U	110. U	220.
Barium (1)	110.	110. U	110. U	NA	110. U	<b>220</b> .	330.
Cadmium (D)	1.0 U	<b>26</b> .	1.0 U	NA.	11.	1.0 U	24.
Cadmium (T)	1.0 U	<b>25</b> .	1.0 U	NA	13.	1.0	33.
Chromium (D)	30. U	30. U	30. U	NA NA	30. U	30. U	30.
Chromium (T)	30. U	30. U	30. U	NA	30. U	113.	200.
Copper (D)	23.	8. U	326.	NA	29.	8.	666.
Copper (T)	25.	8. U	1120.	NA.	149.	101.	27400.
Nickel (D)	30. U	30. U	63.	NA NA	300.	75.	1130.
Nickel (T)	30. U	30. U	75.	NA NA	338.	175.	3750.
	50 U		175.0				
Selenium (0)		338.0		NA NA	225.0	5.0 U	150.0
Selenium (T)	5.0 U	350.0	188.0	NA NA	225.0	5.0 U	168.0
Silver (D)	8.0 U	8.0 U	8.0 U	NA	8.0 U	8.0 U	0.8
Silver (T)	8.0 U	8.0 U	8.0 U	NA	8.0 U	8.0 U	9.0
Thallium (D)	100. U	100. U	100. U	NA	100. U	100. U	100.
Thallium (T)	100. U	100. U	100. U	NA	100. U	100. U	100.
Zinc (0)	10.	116.	<b>263</b> .	NA	<b>65</b> 0.	10.	963.
Zinc (T)	10	119.	738.	NA.	<b>850</b> .	138.	12500.
Lead (0)	25. U	50 N	50. N	NA.	50. N	50. U	38.
Lead(1)	5.0 U	25. U	36.	NA.	<b>150</b> .	25. N	65.
Mercury (T)	0.5 U	0.5 U	NA	NA	NA	NA	NA
Mercury (D)	NA.	NA	NA	NA	NA.	NA	NA.
iron	1090.	450.	11400.	NA	6500.	41300.	323000.
Manganese .	<b>35</b> 30.	200.	63.	NA	75.	3910.	1790.
Magnesium (in mg/l)	110.	9.	810.	NA	620.	770.	410.
upori i i i i i i i i i i i i i i i i i i	<b> </b>	1					
11SCELLANEOUS INORGANICS (in		06	4.005	***	5075	750	7000
Sodium	23.	<b>26</b> .	6625.	NA ***	5275.	<b>750</b> .	3888.
Potessium	9.5	7.7	318.	NA NA	248.	118.	193.
Calcium	- 178.	290.	310.	NA NA	220.	400.	250.
Chloride	12	7.	13400.	NA	10400.	1300.	6800.
Sulfate	<b>75</b> 0.	740.	1900.	, NA	1650.	<b>820</b> .	1150.
Sulfide	0.5 U	0.5 U	0.5 U	NA NA	0.5 U	0.9	0.5
Bicarbonate	<b>160</b> .	86.	43.	NA	15.	<b>262</b> .	38.
Alkalinity	160.	86.	43.	NA	15.	<b>262</b> .	<b>36</b> .
VOLATILE ORGANIC COMPOUNDS	(in ua/l)	1					
Benzene	NA NA	NA	1 U	1 U	1 U	1 U	ı
Toluene	NA.	NA	i	iŭ	ÌŪ	iù	2
Ethylbenzene	NA NA	NA	i u	iŪ	ÌŪ	iŪ	ī
Xylenes	NA NA	NA NA	iŭ	iù	iŭ	iŭ	i
Chloroform	NA NA	NA.	NA NA	. NA	NA .	NA	NA.
EMIYOLATILE ORGANIC COMPOL	Mino (in until	٠					
Dimethylaniline	NA NA	NA	20. U	10. U	20. U	40. U	44.
Total Pre Midrocamordinme "	414	AIA '		0.7	20.4	•	
i otal Oryanic Carbun (ili mg/l)	, NA	NA 1.5 ~	NA.	^.3	0.4	NA	40

Table Continued 8-37 (10/19) B-37 (1/11) HC STATION NO: SPRING 1 SPRING 2 **COOLING POND** SEAWATER B-7 SCREENED AQUIFER FILL FILL **YASHON** COMM, SAND 2 **SURFACE H20 TIDAL STATION** BLANK **6W REGIME:** PLANT PLANT STACK STACK **PLANT** TOTAL METALS (in µg/I) Antimony (D) 80. U NA 80. U 80. U 80. U 80. U 80. U Antimony (T) 288 NA 80 U 80. U 80. U 80. U 80. U Arsenic (D) 10800. NA 101. 44. 64. 10. 6. U Arsenic (T) 12200. NA 313. 300 130. 8. 48. Barium (D) 110. U NA 110. U 110. U 110. U 110. U 110. U Barrium (1) 110. U NA 220. 110. U 110. U 110. U 110. U Cadmium (D) 1.0 U NA 1.0 U 1.0 1.0 U 1.0 U 1.0 U Cadmium (T) 11. NA 1.0 1.0 1.0 U 1.0 U 1.0 U Chromium (D) 30. U NA 30. U 30. U 30. U 30. U 30 U Chromium (T) 38. NA 30. U 30. 30. U 30. U 30. U Copper(D) 8. U NA 81. 20. 63. 20. 13. Copper(T) 4540. NA 234. 368. 126. 29 19. Nickel (D) 188. NA 30. U 30. U 30. U 30. U 30. U Nickel (T) 200. NA 30. U 30. U 30. U 30. U 30. U Selenium (D) 5.0 U NA 5.0 U 5.0 U 5.0 U 5.0 U 5.0 U Selenium (T) 5.0 U NA 5.0 U 5.0 U 5.0 U 50 U 5.0 U Silver (D) 8.0 U NA 8.0 U 8.0 U 11.0 80 U 13.0 Silver (T) 8.0 U NA 8.0 U 8.0 U 11.0 80 U 13.0 Thallium (D) 100. U NA 100. U 100. U 100. U 100. U 100. U Thallium (T) 100. U NA 100. U 100. U 100. U 100. U 100. U Zinc (D) 27750. 25. NA 21. 26. 8.0 U 8.0 Zinc(T) 32500. 34. 74. NA 40. 8.0 8.0 Lead(0) 5.0 N NA 5.0 U 5.0 U 5.0 U 50 N 5.0 U Lesd(T) 775. NA 5.0 U 263. 50. N 5. U 14. Mercury (T) NA NA 0.5 U 05 U 1.8 NA 0.5 U Mercury (D) NA NA NA 05 U NA NA NA 404000. 7130. NA 9380. 1150. 75. 75. Iron 7440. 175. 588. 250. Manganese NA 13. U 13. U Magnesium (in mg/l) 10. NA 13. 13. 17. 980. 0.11 U MISCELLANEOUS INORGANICS (in mg/1) Sodium 25. NA 9.4 9.1 10750. 11. 0.1 U 6.8 Potassium NA 4.4 2.4 3.8 495. 0.1 U Calcium 67. NA 14. 17. 35. 360. 0.11 U Chloride 13. NA 8. 7. 7. 17000. 3. U Sulfate 1700. NA 25. 33. 45. 2300. 3. U **Sulfide** 2.1 NA NA 05 U 0.5 U NA 0.5 U 79. 90. NA 89. Bicarbonate 152. 51. 1. U Alkalinity 79. NA 90. 89. 152. 51. 1. U **YOLATILE ORGANIC COMPOUNDS (in #9/8)** Benzene 17 NA NA NA NA NA 5 U Toluene 5 U NA NA NA NA NA 5 U Ethylbenzene 5 U NA NA NA NA NA 5 U NA. NA NA NA NA Xylenes NA NA 5 V Chloroform NA NA W NA. NA 31 SEMIVOLATILE ORGANIC COMPOUNDS (in µg/I) 10. U Dimethylaniline 400. UR 150000 NA NA. NA NA NA NA NA NA 0.4 Total Pet. Hydrocarbons(inmg/i) NA 0.4

3.7

NA

Total Organic Carbon (in mg/l)

260.

1.8

4.8

0.5 U

Ò.S

6W REGIME:	BLANK	DRILL WATER	ASARCO TAP	
TOTAL HETALS (in µg/l)	<del></del>			
Antimony (D)	80. U	NA	NA	
Antimony (T)	80. U	80. U	80. U	
Arsenic (D)	6. U	' NA	NA	
Arsenic (T)	6. U	18.	6. U	•
Barium (D)	110. U	NA	NA	•
Barium (T)	110. U	110. U	110. U	
Cadmium (D)	1.0 U	NA	NA	,
Cadmium (T)	1.0 U	1.0 U	1.0 U	
Chromium (D)	30. U	NA	NA	
Chromium (T)	30. U	30. U	30. U	
Copper (D)	8.	NA	NA	•
Copper (T)	8.	23.	<b>25</b> .	
Nickel (D)	30. U	NA	NA	
Nickel (T)	30. U	30. U	30. U	
Selenium (D)	5.0 U	NA	NA	
Selenium (T)	5.0 U	5.0 U	5.0 U	
Silver (D)	U 0.6	NA	NA.	
Silver (T)	8.0 U	8.0 U	8.0 U	
Thallium (D)	100. U	NA	NA	
Thellium (T)	100. U	100. U	100. U	
Zinc (D)	8.0 U	NA	NA	
Zinc (T)	8.0 U	213.	150.	
Lead(D)	5.0 U	NA	NA	
Lend(T)	5. U	5.0 U	11.	·
Mercury (T)	05 U	0.5 U	0.5 U	
Mercury (D)	NA	NA	NA	•
Iron	50.	. NA	NA	
Manganese	13. U	NA	NA.	
flagnesium (in mg/l)	0.11 U	NA	NA	
(in mg/l)	I			
Sodium	0.1 U	NA	NA	
Potessium	0.1 U	NA	NA	
Calcium	0.11 U	NA	NA	
Chloride	3. U	NA	NA	
Sulfate	3. U	NA	NA	
Sulfide	0.5 U	NA.	NA NA	
Bicarbonate	1. U	NA	NA.	
Alkalinity	1. U	NA	NA	
وير OLATILE ORGANIC COMPOUNDS (in ا	<b>/1)</b>			•
Benzene	NA	5 U	5 U	
Toluene	NA	5 U	5 U	
Ethylbenzene	NA	5 U	5 U	
Xylenes	NA	NA .	NA	
Chloroform	NA	35	33	
EMIYOLATILE ORGANIC COMPOUNDS (i				
Dimethylaniline	NA	NA	NA	
Total Production of in mg/l)	, NA	NA	₩.	

## Summary of Chemical Analysis of Groundwater (Phase I)

HC STATION NO: SCREENED AQUIFER: GW REGIME:	HW 1A2 FILL PLANT	MW 1B FILL PLANT	HW 2A FILL PLANT	MW 28 FILL PLANT	MW 3A2 FILL PLANT	MW 38 FILL PLANT	MW 4 FILL PLANT
DISSOLVED AND TOTAL HETALS (in jig	<b>/</b> 1)						•
Antimony(D)	80 U	310	80 U	80 U	80 U .	80 U	80 U
Antimony(T)	80 U	330	80 U	80 U	80 U	80 U	80 U
Arsenic(D)	6300	363	25600	15000	84	16	69
Arsenic(T)	6300	363	27500	15000	105	23	2 <del>4</del> 5
Barium(D)	110 U	110 U	. 110	110 U	110	220	110 U
Barium(T)	110	110	110	110 U	220	220	220
Cadmium(D)	10 U	375	15	50	3.0	3.0	1.0 U
Cadmium(T)	9.0	388	20	55	4.0	3.0	1.0 U
Chromium(D)	30 U	30 U	30 U	30 U	30 U	30 U	30 U
Chromium(T)	30 U	30 U	30 U	30 U	30 U	30 U	30 U
Copper(D)	18	2900	133	1100	135	380	600
Copper(T)	180	3000	129	1200	141	390	600
Lead(D)	50 U	50	50 U	50 U	50 U	50 U	5.0 U
Lead(T)	90	50	50 U	50 U	50 U	50 U	30
Nickel(D)	30 U	50	63	88	175	75	750
Nickel(T)	30 U	50	75	88	175	75	540
Selenium(D)	50 U	5.0 U	5.0 U	50 U	50 U	5.0 U	5.0 U
Selenium(T)	50 U	5.0 U	50 U	50 U	5.0 U	5.0 U	5.0 U
Silver(D)	80 U	8.0 U	8.0 U	80 U	8.0 U	8.0 U	8.0 U
Silver(T)	0 Q8	8.0 U	U 0.8	U 0.8	8.0 U	8.0 U	8.0 U
Thallium(D)	213	225	225	110	375	375	100 U
Thallium(T)	213	225	225	110	368	400	100 U
Zinc(D)	23	5400	1150	3100	280	320	. 25
Zinc(T)	440	5400	1850	3300	260	330	100
Hercury(T)	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Sulfide (in µg/1)	200 U	900	2400	2000	200 ∪	200 U	200 U

Continued

HC STATION NO: SCREENED AQUIFER; 6¥ REGIME:	MW 5 FILL PLANT	MW 6 FILL PLANT	MW 8 FILL PLANT	MW 0 FILL PLANT	MW 12 FILL PLANT	MW 13 GLACIAL DRIFT PARKING LOT	SPRING 1 YASHON ADY. STACK AREA
DISSOLVED AND TOTAL METALS (in mg/	1)						
Antimony(D)	80 U	80 U	U 08				
Antimony(T)	80 U	80 U	80 U	U 08	80 U	80 U	80 U
Arsenic(D)	11	10	20600	323	781	8.0	71
Arsenic(T)	31	15	20600	356	894	10	73
Berlum(D)	110 U	110 U	110 U	110	220	110	110 U
Berium(T)	550	110	110 U	110	440	110	110 U
Cadmium(D)	10 U	1.0	10 U	1.0	1.0 U	1.0 U	1.0 U
Codmium(T)	10	1.0	10 U	3.0	100	1.0	1.0
Chromium(D)	30 U	30 U	30 U				
Chromium(T)	240	30 U	30 U	30	190	30 U	30 U
Copper(D)	13	8.0 U	11	U Q.8	8.0 U	8.0 U	38
Copper(T)	194	10	14	49	94	25	38
Lead(D)	50 U	50 U	50.0 U	50 U	5.0 U	50 U	5.0 U
Lead(T)	40	50 U	50 U	30	30	5.0 U	50 U
Nickel(D)	30 U	30 U	30 U				
Nickel(T)	163	30 U	30 U	30 U	113	30 U	30 U
Selenium(D)	5.0 U	50 U	5.0 U	50 U	50 U	5.0 U	5.0 U
Selenium(T)	50 U	5.0 U	5.0 U	50 U	5.0 U	5.0 U	5.0 U
Bilver(D)	8,0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Bilver(T)	8.0 U	U Q.8	8.0 U	8.0 U	U 0.8	8.0 U	U 0.8
Thallium(D)	100 U	100 U	100	100 U	100 U	100 U	100 U
Thallium(T)	100 U	100 U	110	100 U	100 U	100 U	100 U
Zinc(D)	8.0 U	8.0	8.0	8.0	23	19	31
Zinc(T)	243	11	8.0	96	209	73	31
Hercury(T)	0.50 U	0.50 U	0.50 U				
Sulfide (in µg/l)	1300	200 U	3100	1200	2600	1700	1500

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APPENDIX L

Little Little Concession

TILL LEACHING

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Table L-1 Summary of Chemical Analysis of Leaching Test Soils

TEST PIT NO: SAMPLE DEPTH:	TP-1 2.5 - 4	TP-2 4 - 6	TP-3 1.5 - 2.5	TP-5 1.5 ~ 3.5	TP-6 2 - 3.5	TP-7 1.5 - 2.5	TP-8 0.5 - 2
MATRIX:	SAND FILL	SILT	SAND FILL	SLAG/ORE	SILT FILL	SAND FILL	SLAG
TOTAL HETALS (in mg/kg)							
Antimony	114.	13. U	13. U	89.	13. U	13. U	278.
Arsenic	<b>2305</b> .	<b>56</b> .	<b>4200</b> .	5175.	20375.	10.	9950.
Barium	38.	71.	80.	405.	31.	89.	615.
Cadmium	0.50 U	7.1	17.	<b>23</b> .	6.9	9.0	24.
Chromium	71.	82.	119.	209.	76.	86.	698.
Copper	217.	<b>3700</b> .	1633.	815.	<b>515</b> .	136.	45250.
Lead	1623.	478.	<b>23</b> 56.	3425.	13.	160.	11950.
Mercury	11.	5.1	5.4	27.	17.	0.34	0.56
Nickel	. 68.	65.	94.	162.	42	<b>75</b> .	640.
Selenium	<b>25</b> .	43.	13. U	<b>27</b> .	<b>35</b> .	19.	46.
Silver	16.	7.9	9.8	46.	3.2	3.8	9.8
Thallium	13. U	13. U	13. U	13. U	13. U	13. U	15.
Zinc	<b>263</b> .	693.	400.	3750.	150.	<b>398</b> .	20400.
EP-TOXICITY METALS (in mg/1)							
EPTOX Arsenic	0.27	0.010	3.5	0.097	31	0.033	0.013
EPTOX Silver	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	U 800.0
EPTOX Barium	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
EPTOX Cadmium	0.02 U	0.032	0.063	0.051	0.020 U	0.020 U	0.020 U
EPTOX Chromium	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U	0.033 U
EPTOX Mercury (in µg/1)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
EPTOX Lead	0.033 U	0.033 U	0.15	0.094	0.033 U	0.033 U	0.033 U
EPTOX Selenium	0.083 U	0.083 U	0.083 U	0.083 U	0.083 U	0.083 U	0.083 U
EPTOX Copper	0.024	1.4	4.2	1.7	0.99	0.017 U	1.6
EPTOX Zinc	0.12	0.93	2.1	<b>2</b> .1	0.67	0.24	0.11
pH	5.8	4.9	4.4	5.0	4.2	6.4	5.4

4. 40 at 74 by 1. 4 (4) 15 (1. 44 ft).

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## Chemical Analysis of Leaching Test Water

TEST PIT NO:	TP-1	TP-1	TP-1	TP-I	TP-1	TP-3
PORE YOLUME:	PY-I	PY-2	PY-3	PY-4	PV-5	PY-I
DISSOLVED METALS (in µg/I)						
Antimony	400.	488.	863.	925.	900.	80. U
Arsenic	413.	713.	1030.	4360.	20100.	27100.
Barium	110. U	110.	110.	110. U	110. U	110. U
Cadmium	1.0	1.0 U	1.0 U	1.0 U	1.0 U	2340.
Chromium	3Q U	30. U	30. U	30. U	30. U	30. U
Copper	41.	131.	54.	43.	8.0 U	175400.
Lead	25. U	5.0 N	50 N	5.0 U	5.0 U	363.
Hercury	0.5 N	0.5 N	0.5 N	05 N	0.5 N	0.5 N
Nickel	613. J	250. J	125. J	100. J	175. J	325. J
Selenium	838.	6.0	9.0	5.0 U	5.0 U	163.
Silver	8.0	8.0 U	8.0 U	8.0 U	8.0 U	8.0
Thallium	100. U	100. U	100. U	100. U	100. U	100. U
Zinc	<b>398</b> .	75.	81.	41.	29.	97500. J
рН	6.5	6.6	6.8	7.0	7.1	4.3

				• • • • • • • • • • • • • • • • • • • •		
TEST PIT NO: PORE VOLUME:	TP-3 PY-2	TP-3 PY-3	TP-3 PY-4	TP-3 PY-5	TP-6 PY-1	TP-6 PY-2
DISSOLYED METALS (in µg/l)						
Antimony	80. U	80. U	80. U	80. U	80. U	80. L
Arsenic	<b>32900</b> .	26800	27800.	27100.	403100.	<b>371900</b> .
Barium	110. U	110.	110.	11Q. U	110. U	110. L
Cadmium	838.	425.	268.	235.	<b>134</b> .	88.
Chromium	30. U	30. U	30. U	30. U	30. U	30. l
Copper	63500.	33500.	22600.	17800.	18800.	11200.
Lead	200.	125.	86.	32	5.0 N	5.0 A
Mercury	0.5 N	0.5 N	05 N	0.5 N	40. J	18. J
Nickel	913. J	525. J	375. J	375. J	300. J	188. J
Selenium	125.	31.	29.	8.0	5.0 U	5.0 L
Silver	<b>35</b> .	10.	8.0 U	8.0 U	8.0 U	8.0 L
Theilium	100. U	100. U	100. U	110. U	100. U	100. l
Zinc	31900. J	16600. J	10600. J	9000. J	10700. J	6700. J
На	43	45	45	4.6	3.9	3.9

Table Continued

TEST PIT NO: PORE YOLUME:	TP-6 PY-3	TP-6 PV-4	TP-6 PY-5	TP~7 PY~1	TP-7 PY-2	TP-7 <b>PY-3</b>	TP-7 PV-4
Antimony	80. U	80 U	80 U				
Arsenic	360600.	328800.	300000.	16.	23.	15	56
Barium	110. U	110.	110. U	110.	110. U	110 U	110
Cadmium	46.	36.	34.	20.	20.	13.	8.0
Chromium	30. U	30 U	30 U				
Copper	6540.	5400.	4610.	26.	9.0	14	8.0
Lead	5.0 U	5.0 U					
Mercury	9.9 J	3.8 J	2.1 J	0.5 N	05 N	0.5 N	0.5 N
Nickel	125. J	100. J	100. J	125. J	213. J	168 J	213 J
Selenium	5.0 U	5.0 U					
Silver	8.0 U	8.0 U	8.0 U	8.0 U	U 0.6	18.	8.0 U
Thallium	100. U	100. U	100. U	100. U	100. U	100 U	100 U
Zinc	3800. J	3000. J	2700. J	<b>541</b> .	138.	174	59.
рН	4.0	4.0	4.0	7.1	6.9	7.1	6.9

TEST PIT		TP-8 PV-1	TP-6 PY-2	TP-8 PY-3	TP-8 PY-4	TP-8 PY-5	LM-1 STARTING H20
DISSOLVED HETALS (in µg/i	)						
Antimony	80. U	400.	<b>525</b> .	363.	125.	80. U	80. U
Arsenic	19.	100.	94.	<b>36</b> .	34.	41.	6.0
Barium	110. U	110. U	110. U	110.	110.	110.	110. U
Cadmium	3.0	1.0	1.0	1.0	3.0	40	3.0
Chromium	30. U	30. U	30. U	30. U	30. U	30. U	30. U
Copper	8.0 U	63.	9.0	<b>39</b> .	163.	69.	8.0
Lead	5.0 U	5.0 U	5.0 U	5 <u>.0</u> U	5.2	50 U	5.0 U
Mercury	0.5 N	0.5 N	0.5 N	05 N	05 N	05 N	0.5 N
Nickel	113. J	125. J	113. J	113. J	113. J	130. J	30. N
Selenium	5.0 U	5.0 U	5.0 U	50 U	5.0 U	50 U	50 U
Silver	U Q.6	8.0 U	U 0.6	U 0.6	U 0.8	U QB	8.0 U
Thailium	100. U	100. U	100. U	100. U	100. U	100. U	100. U
Zinc	35.	393.	41.	64.	123.	79.	8.0
pH .	72	7.7	75	7.6	7.3	75	8.

APPENDIX M

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MARINE SURFICIAL SEDIMENT

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (TOTAL METALS)

					•		
				Arsenic	Copper	Lead	Zinc
Sta	ld	Anl	Event	ppe	ppa	bbw	pps
MCM.	-2	TOT	ROUND-1	9.000J	39.000	26.000	AB.000
			ROUND-1	120.000J	152.000	118.000	406.000
			ROUND-1	21.0003	27.000	32.000	105.000
			RDUND-1	23.000J	60.000	52.000	118.000
			RDUND-1	320.000J	218.000	251.000	850.000
			ROUND-1	240.000J	147.000	158.000	530.000
			ROUND-1	70.000J	50.000	72.000	273.000
			ROUND-1	1620.000J	1145.000	1805.000	6940.000
			ROUND-1	555.000J	381.000	B30.000	4305.000
			ROUND-1	170.000J	290.000	477.000	2115.000
			ROUND-1	905.000J	725.000	1040.000	4630.000
			ROUND-1	4915.000J	3115.000	4650.000	18000.000
			ROUND-1	4600.000J	2545.000	6100.000	1625.000
			ROUND-1	4985.000J	2225.000	3785.000	11450.000
			ROUND-1	100.0003	615.000	191.000	990.000
			ROUND-1	6450.000J	3245.000	5400.000	19050.000
			ROUND-1	8950.000J	3450.000	6650.000	1700.000
			ROUND-1	1400.000J	B00.000	1355.000	3830,000
			ROUND-1	85.0003	725.000	145.000	378.000
			ROUND-1	8400.000J	2985.000	9400.000	20850.000
			ROUND-1	6350.0003	3260.000	5550.000	16750.000
			ROUND-1	1520.000J	930.000	1630.000	4290.000
			ROUND-1	100.000J	49.000	85.000	202.000
			ROUND-1	3620.000J	7600,000	2450.000	5360.000
			ROUND-1	6700.0003	3360.000	5000.000	17500.000
			RBUND-1	5050.000J	2535.000	4625.000	19000.000
			RDUND-1	100.0003	64.000	72.006	215.000
			ROUND-1	65.000J	51.000	39,000	117,000
			ROUND-1	18,0003	35.000	26.000	71.000
			ROUND-1	16.000J	16.000	26.000	54.000
			ROUND-1	4585.000J	195.000	3540.000	12100.000
			ROUND-1	565.000J	444.000	462.000	1285.000
					-		

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (TOTAL METALS)

Sta Id	A-1	Event	Arsenic	Copper	Lead	linc
219 10	M111	EASHE	pps	₽₽€	рра	рра
MSM-08-3	TOT	ROUND-1	320,000J	163.000	118.000	394.000
MSM-0B-4			160,0003	125.000	105.000	330.000
MSM-09-1	TOT	ROUND-1	5950.000J	8950.000	3670.000	5450.000
MSH-09-2			200.000J	248.000	158.000	355.000
MSM-09-3	TOT	ROUND-1	65.0003	82.000	52.000	155.000
HSH-09-4	TOT	ROUND-1	29.000J	55.000	39.000	92.000
MSM-09-5	TOT	ROUND-1	16.0003	36.000	39.000	75.000
MSM-09-6	TOT	ROUND-1	25.000J	25.000	32.000	75.000
MSM-09-7	TOT	ROUND-1	12.000J	18.000	19.000	<b>62.000</b>
HSM-09-B	TOT	ROUNG-1	9.500J	19.000	19.000	58.000
MSM-10-0	TOT	ROUND-1	4105.000J	18300.000	3910.000	4080.000
MSM-10-1	TOT	ROUND-1	665.000J	1665.000	690.000	1010.000
MSH-10-2	TOT	ROUND-1	170.000J	243.000	118.000	330.000
MSM-10-3	TOT	ROUND-1	38.000J	53.000	39.000	100.000
MSM-10-4	TOT	ROUND-1	42.000J	58.00 <b>0</b>	39.000	109.000
MSM-11-1	TOT	ROUND-1	4995.000J	12600.000	3135.000	2430.000
MSM-11-2	TOT	ROUND-1	410.000J	1075.000	3B1.000	505.000
MSM-11-3	TOT	ROUND-1	55.000J	106.000	59.000	100.000
MSH-11-4	TOT	ROUND-1	47.000J	BO.000	46.000	121.000
MSM-11-5	101	ROUND-1	28.000J	50.000	39.000	104.000
MSM-11-6	TOT	ROUND-1	21.000J	87.000	39.000	92.000
HSM-11-7	TOT	ROUND-1	12.000J	19.000	26.600	58. <b>0</b> 00
MSM-11-8	TOT	ROUND-1	12.0001	20.000	26.000	82.000
MSM-11-9	101	ROUND-1	7.5003	15.000	26.000	54.000
MSM-12-1	TOT	ROUND-1	<b>505</b> 0.000J	7650.000	4585.000	5100.000
MSH-12-2			190.0063	497.000	138.000	217.000
MSH-12-3			<u> 60.0</u> 00ј	200.000	72.000	151.000
MSH-12-4			35.000J	60.000	39.000	79.066
MSH-12-5			16.0003	46.000	46.000	83.000
MSM-13-1			2340.0003	5400.000	<b>2510.0</b> 60	1700.000
MSH-13-2			60.000J	152.000	59.000	8B.000
MSM-13-3	TOT	ROUND-1	82.000J	130.000	59.000	121.000

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (TOTAL METALS)

				Arsenic	Copper	' Lead	Zinc
Sta	Id	Anl	Event	ррв	. pp <b>a</b>	ppa	ppa
HSM-	13-4	TOT	ROUND-1	24.000J	47.000	39.000	71.000
MSM-	13-5	TOT	ROUND-1	15.000J	23.000	26.000	49.000
MSM-	13-6	TOT	ROUND-1	33.000J	16.000	19.000	41.000
MSH-	13-7	TOT	ROUND-1	12.000J	17.000	32.000	54.000
MSM-	13-8	TOT	KOUND-1	11.000J	14.000	19.000	45.000
MSM-	14-1	101	ROUND-1	11100.000J	3850.000	3405.000	7600.000
MSM-	14-2	TOT	ROUND-1	160.000J	306.000	105.000	249.000
MSM-	14-3	TOT	ROUND-1	35.000J	179.000	65.000	134.000
MSM-	14-4	TOT	ROUND-1	60.000J	46.000	39.000	75.000
HEM-	14-5	TOT	ROUND-1	29.000J	31.000	32.000	71.000
MSH-	15-2	TOT	ROUND-1	290.000J	300.000	118.000	296.000
MSM-	15-3	TOT	ROUND-1	47.000J	72.000	46.000	79.000
MSM-	15-4	TOT	ROUND-1	30.000J	37.000	32.000	71.000
HSM-	15-5	TOT	ROUND-1	13.000J	32.000	26.000	58.000
MSM-	16-1	TOT	ROUND-1	270.000J	190.000	59.000	141.000
MSM-	16-2	TOT	ROUND-1	75.0003	57.000	32.000	64.000
HSH-	16-3	TOT	ROUND-1	26.000J	27.000	19.000	46.000
MSM-	16-4	TOT	ROUND-1	11.000J	24.000	13.000	50.000
MSM-	17-1	TOT	ROUND-1	210.000J	910.000	217.000	223.000
HSM-	17-2	TOT	ROUND-1	39.000J	<b>B4.00</b> 0	26.000	46.000
MSM-	17-3	TOT	ROUND-1	21.000J	52.000	32. <b>0</b> 00	£4.000
Meh-	17-4	TOT	ROUND-1	7.G0 <b>0</b> J	26.000	19.000	46.000
MSM-	18-1	TOT	ROUND-1	A5.000J	295.000	72.000	109.000
MSM-	18-2	TOT	ROUND-1	35.000J	71.000	32.000	64.000
			ROUND-1	26.000J	3 <b>8.</b> 000	26.000	46.000
MSM-	19-1	TOT	ROUND-1	26.300J	77.000	26.000	37.000
MSM-	19-2	TOT	ROUND-1	120.0003	<b>52.000</b>	26.000	41.000
HSM-1	20-1	TOT	ROUND-1	11.000J	51.000	13,000	28.000
			ROUND-1	20.0003	54.000	32,000	41.000
			ROUND-1	18.000J	94.000	39.000	59.000
			ROUND-1	26.G00J	74.000	39.000	128.000
MSM-	21-3	TOT	ROUND-1	32.0003	87.000	46.000	114.000

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (TOTAL METALS)

Sta Id	Anl	Event	Arsenic ppm	pp <b>e</b> Copper	Lead ppm	' Zinc pps
HSH-22-1	TOT	ROUND-1	18.000J	90.000	105.000	105.000
MSH-22-2	TOT	ROUND-1	39.000J	156.000	178.000	191.000
MSN-22-3	TOT	ROUND-1	11.0003	49.000	39.000	64.000
REP-1	TOT	ROUND-1	22.000J	43.000	39.000	B3.000
REP-3	TOT	ROUND-1	18.0003	22.000	13.000	50,000
REP-4	TOT	ROUND-1	5750.000J	3335.000	7300.000	20550.000

		Arsenic	Copper	Lead	Mercury	Zinc
Sta Id A	Ani Event	ppa	ppa	ppa	ppb	ppa
71-1	FOT ROUND-2	19.000	50.000	33.000	275.0000J	AB. 000
	FOT ROUND-2	590.000	1873.000	BA0.000	1800.00003	1000.000
	IDT ROUND-2	95.000	152.000	77.000	600.0000J	176.000
	FOT ROUND-2	13,000	21.000	28.000	60.0000J	55.000
T12-1 1	TOT ROUND-2	2355.000	8200.000	3275.000	5400.0000J	3975.000
714-2	TBT_ROUND-2	49.000	148.000	59.000	250.0000	141.000
714-2, L 1	TOT ROUND-2	58.000	225.000	6475.000	120.0000	483.000
T14-2, M 1	TOT ROUND-2	102,000	238.000	95.000	310.0000	162.000
114-2, R	TOT ROUND-2	60.000	15B.000	73.000	270.0000	147.000
T14-2, S 1	TOT ROUND-2	145.000	373.000	108.000	530.0000	213.000
T15-1	TOT ROUND-2	20225.000	4600.000	4430.000	5400.0000	2825.000
715-1, L	TOT ROUND-2	B475.000	4725.000	4650.000	B300.0000	7500.000
T15-1, K	TOT ROUND-2	17500.000	4800.000	3625.000	16000.0000	2800.000
715-1, R 1	TOT ROUND-2	20575.000	4900.000	<b>4500.0</b> 00	18000.0000	2875.000
115-1, S	TOT ROUND-2	18025.000	5725.000	4025.000	40000.0000	1428.000
716-1	TOT ROUND-2	4B.000	141.000	44.000	220.0000J	B1.000
T16-4	TOT ROUND-2	16.000	21.000	19.000	70.000GJ	53.000
T18-2	TOT ROUND-2	33.000	65-000	35.000	120.0000J	55.000
72-1	TOT ROUND-2	30.000	120.000	65.000	735.0000J	110.000
12-5	TOT ROUND-2	27.000	23.000	35.000	50.0000J	91.000
12-6	TOT ROUND-2	36.0003	27.000J	44.000J	75.0000J	111.000J
12-60	TOT ROUND-2	34.000J	2B.000J	53.0000	55.0000J	109.000J
T22-1	TOT ROUND-2	49.000	138.000	117.000	300.0000	145.000
122-2	TOT ROUND-2	46.000	104.000	620.000	340.0000	185.000
72A-5	TOT ROUND-2	83.000J	62.000J	109.0003	270.0000J	355.000J
13-2	TOT ROUND-2	455.000	244.000	488.000	140.0000	2275.000
13-20	TOT ROUND-2	485.000	248.000	540.000	170.0000	2420.000
73-4	TOT ROUND-2	2378.000	998.000	7600.000	260.0000J	11250.006
13-5	TOT ROUND-2	1940.000	793.900	1545,000	280.00003	\$175,000
13-6	TOT ROUND-2	1130,000	468.000	B45.000	250.0000J	2725.000
T4-1	TOT ROUND-2	7300.000	3500.000	<b>7900.</b> 000	200.0000	19700.000

MARINE SEDIMENT SAMPLES - (TOTAL METALS)

Sta Id	Anl Event	Arsenic pps	Copper ppm	Lead ppe	:	Zinc ppm
T4-1, L	TOT ROUND-2	5575.000	3425.000	7425.000	150.0000	18100.000
T4-1, M	TOT ROUND-2	5575.000	3075.000	6425.000	350.0000	15875.000
74-1, R	TOT ROUND-2	5325.000	2600.000	6075.000	300.0000J	14750.000
74-1, S	TO? ROUND-2	744.000	2950.000	1435.000	2100.0000	1748.000
14-2	TO? ROUND-2	7350.000	3025.000	6725.000	170.0000	17625.000
14-2	TOT ROUND-2	6B25.000	2925.000	6200.000	140.0000	14825.000
14-2, L	TOT ROUND-2	7075.000	3175.000	7600.000	280.0000	19875.000
T4-2, H	TOT ROUND-2	3900.000	1673.000	3000.000	250.0000	8650.000
T4-2, R	TOT ROUND-2	6000.000	2675.000	5975.000	210.0000	15550.000
T4-2, S	TOT ROUND-2	2305.000	618.000	820.000	550.0000	1908.000
T4-4	TOT ROUND-2	26.000	20.000	31.000	90.0000J	95.000
15-0	TOT ROUND-2	86.000	805.000	243.000	340.00003	1200.000
16-1	10T ROUND-2	9150.000	3375.000	9975.000	160.0000J	21800.000
16-3	TOT ROUND-2	2550.000	1203.000	2223.000	250.0000J	5800.000
TE-4	TOT ROUND-2	55.000	70,000	62,000	190.0000J	143.000
TO-2	TOT ROUND-2	14.000	30.000	24.000	95.00003	60.000
10-3	TOT ROUND-2	95.000	B0.000	88.000	135.00003	225.000

MARINE SEDIMENT SAMPLES - (EP TOXICITY)

Sta Id	Anl Event	Arsenic ppm	auints) agg	Chromium ppm	Lead ppa	Mercury ppb	Seleniuz ppa	Silver ppm	Bariua ppa	pH
T1-1	EPT ROUND-2	0.330<	0.02004	0.0334	9.020K	0.5000N	0.0839<	0.0080<	0.50<	B. 9
710-1	EPT ROUND-2	0.330	0.0200	0.0334	0.100	0.5000N	0.0800(	0.0080	0.564	B. 2
110-1	EPT ROUND-2	0.330(	0.00304	0.033(	0.067	0.5000N	0.08004	0.00800	0.56<	8.Z 8.3
T11-7	EPT ROUND-2	0.330	0.00304	0.033(	0.0204	0.5000N	0.0800<	0.0080(	0.56<	B. 3
T12-1	EPT ROUND-2	0.330	0.0250	0.033(	0.520	0.5000N	0.08000	0.00804	0.564	B. 4
	EPT ROUND-2	0.330		0.0334	0.020	0.5000N	0.08000			
116-1			0.00304					0.00804	0.564	B. 3
716-4	EPT ROUND-2	0.330(	0.0030(	0.0334	0.0294	0:5000N	0.0800(	0.0080(	0.564	8.1
T18-2	EPT ROUND-2	0.330(	0.0030(	0.0334	0.020(	0.5000N	0.08004	0.00904	0.56	7.B
T2-1	EFT ROUND-2	0.3304	0.02004	0.0334	0.020(	0.5000N	0.08304	0.00804	0.50<	8.7
12-5	EFT ROUND-2	0.330<	0.0030{	0.0334	0.0204	0.5000(	0.0803(	0.00800	0.564	8.7
12-6	EPT ROUND-2	0.330<	0.00304	0.0334	0.020(	0.5000N	0.08000	0.0080(	0.56<	B.7
12-60	EPT ROUND-2	0.330(	0.0030<	0.033<	0.020<	0.5000N	0.0800(	0.0080<	0.56<	6.6
122-1	EPT ROUND-2	0.330<	0.0030	0.033<	0.020(	0.5000<	0.08004	0.0080<	0.56<	8.1
122-2	EFT ROUND-2	0.330<	0.0050	0.033<	0.020	0.5000<	0.08004	0.00804	0.5&<	7.9
12A-5	EPT ROUND-2	0.3304	0.00304	0.033<	0.020<	0.5000N	0.0300(	0.0080<	0.564	8.4
13-2	EPT ROUND-2	0.330<	0.00304	0.0334	0.020(	0.50000	0.0B00<	0.00804	0.56<	7.2
13-20	EPT ROUND-2	0.330<	0.00304	0.0334	0.020(	0.5000<	0.0800(	0.0080<	0.560	8.2
13-4	EPT ROUND-2	0.330<	0.00304	0.0334	0.0204	0.50004	0.08004	0.0080<	0.56<	8.4
13-5	EPT ROUND-2	0.330<	0.00364	0.033<	0.070	0.5000(	0.08000	0.00804	0.564	7.7
T3-6	EPT ROUND-2	0.330(	0.00304	0.0334	0.020(	0.5000<	0.08000	0.00804	0.56(	8.5
14-2	EPT ROUND-2	0.830	0.00394	0.0334	0.0204	0.5000<	0.08004	0.00804	0.55(	8.3
T4-4	EPT ROUND-2	0.330(	0.0030	0.0334	0.0204	0.5000(	0.0B00<	0.0080(	0.534	B.3
15-0	EFT ROUND-2	0.330	0.00304	0.033<	0.033	0.5000N	0.08004	0.0080(	0.56<	8.2
76-1	EPT ROUND-2	0.330	0.00304	0.0334	0.020	0.5000(	0.0B00(	0.0080(	0.564	8.2
16-3	EPT ROUND-2	0.330(	0.0030	0.0334	9.020	0.5000	0.08000	0.00804	0.564	8.2
						0.50000			0.56	3.4
18-4	FPT ROUND-2	0.330(	0.0030(	0.033(	0.020		0.0800(	0.00804		
10-2	EPT ROUND-2	0.330(	0.02004	0.0334	0.020(	0.5000N	0.0930<	0.00800	0.50(	B.7
10-3	EPT ROUND-2	0.330<	0.0206<	0.033(	9.0764	0.500CN	0.0830(	0.00800	0.504	9.1

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta Id	Anl Event	Benzoic Acid ppb	2-Chloro phenol ppb	2,4-Di chloro phenol ppb		2,4-Di nitro phenol ppb	•	4-Methyl phanal ppb	2-Nitro phenol ppb	4-Nitro phenol ppb	4-Chloro- 3-methyl phanol ppb
METH-10	TOT ROUND-1	1700.00{	330.00(	330.00(	330.004	1700.00	330.004	330.00{	330.000	1700.004	330.000
METHOD-1	TOT ROUND-1	B30.00<	170.004	170.00(	170.00(	B30.00(	170.00<	170.004	170.00	B30.00{	170.000
METHOD-7	TOT ROUND-1	1700.00(	330.00<	330.00(	330.00<	1700.000	330.00(	330.00<	339.00(	1700.004	330.000
KETHOD-8	TOT ROUND-1	1700.000	330.00<	330.004	330.00(	1700.000	330.00<	330.004	330.00(	1700.000	330.000
METHOD-9	TOT ROUND-1	1700.004	330.00(	330.00(	330.00(	1700.00{	330.00(	330.000	330.000	1700.000	330.000
HS17-1DF	TOT ROUND-1	3400.004	2500.00	660.004	£60.00(	3400.00<	P60.00(	>00.044	660.000	4500.00	2700.00
MS17-1MS	TOT ROUND-1	3400.004	2500.00	660.000	660.004	3400.064	460.00(	440.004	£60.00<	4700.00	2800.00
MSA-0MSD	TOT ROUND-1	1700.000	3120.00	330.004	330.00(	1700.000	330.090	330,004	330.00(	3120.00	5640.00
MS7-6MSD	TOT ROUND-1	1700.000	2000.00	330.00<	330.00(	1700.000	330.004	330.00<	330.00(	1800.00	960.00
MS7-7MSD	TOT ROUND-1	1700.000	1600.00	330.00<	330.0 <b>0</b> 0	1700.000	330.004	330.00{	330.00(	2900.00	2530.00
MSB-0-1	TOT ROUND-1	2000.000	300.00(	300.004	300.000	20 <b>0</b> 0.00(	300.600	300.004	300.00(	2000.004	300.00<
MSD-0-2	TOT ROUND-1	2000.00(	400.00<	400.004	400.004	2000.000	400.00<	400.00<	400.00<	2000.004	400.00{
MS0-0-3	TOT ROUND-1	2000.00{	400.00<	400.00<	400.004	2000.000	400.000	400.000	400.00<	2000.004	400.004
KS0-01-1	TOT ROUND-1	2000.000	400.00(	400.004	400.000	2000.00<	<b>400.</b> 00(	400.00<	400.00<	2000.00(	400.000
MSG-02-1	TOT ROUND-1	2000.00{	400.00<	400.004	400.004	2000.000	400.00(	400.000	460.004	2000.00{	400.000
MS0-02-2	TOT ROUND-1	3000.000	500.004	500.004	500.004	3000.000	500.00<	570.00	500.00(	3000.000	500.004
MSO-02-3	TOT ROUND-1	2000.000	400.004	400.000	400.000	2000.000	400.00K	400.000	400.000	2000.000	400.004
MSD-03-1	TOT ROUND-1	3000.00N	400.00	400.00M	600.00N	3000.00N	400.00<	\$00.004	600.00N	3000.00W	400.00N
MED-03-2	TOT ROUND-1	2000.000	400.00<	409.00<	400.00(	2000.000	400.00(	400.000	400.00(	2000.000	400.00
MSD-03-3	TOT ROUND-1	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N
MSD-04-0	TOT ROUND-1	3060,00N	500.00N	500.00N	500.00N	3000.000	500.90%	500.00n	500.00N	3000,000	500.00N
MSD-04-1	TOT ROUND-1	2000.00(	400.00(	400.064	400.004	2000.004	400.064	400.000	400.004	2000.000	400.004
MSD-04-2	TOT ROUND-1	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.001	400.00N	400.00N	2000.00N	400.GON
MSB-04-3	TOT ROUND-1	3000.000	500.00(	<b>5</b> 00.00K	500.000	3000.000	<b>500.</b> 00(	5 <b>0</b> 0.00(	500.004	3000.000	500.00(
MSD-05-0	TOT ROUND-1	2000.000	500.00(	500.000	500.000	2000.000	500.00(	500.000	500.004	2000,000	500.004
MSD-05-1	TOT ROUND-1	2000.000	400.00(	400.000	400.000	2000.000	490.000	466.060	400.004	2000.064	400.000
	TOT ROUND-1	2000.004	400.000	400.00(	400.000	2000.000	400.000	400,000	400.000	2000.000	400.004
M50-05-3	TOT ROUND-1	2000.004	400.000	400.000	460.004	2000.000	400.000	400.000	400.000	2000.000	<b>40</b> 0.000
MS0-06-0	TOT ROUND-1	3000.000	∆00.00<	600.000	600.00(	3000.004	<b>600.00</b> 0	400.000	800.000	3000.000	400.000
MSB-06-1	TO? ROUND-1	2000.00(	<b>40</b> 0.000	400.00¢	400.000	2000.004	400.007	400.004	400.090	2000.000	400.000

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

	Benzoic	2-Chloro	2,4-Di chlora	2,4-Di methyl	2,4-Di nitro	2-Methyl	4-Methyl	2-Nitro	4-Nitro	4-Chlora- 3-methyl
	Acid	phenol	phenol	phenol	phenol	phenal	phenol	phenol	phenol	phenol
Sta Id Anl Event	рръ	ppb	ppp	bbp	ppb	ppb	ppb	ppb	ppb	ррь
MSD-06-2 TOT ROUND-1	2000.00<	400.00(	400.004	400.004	2000.004	400.00(	400.004	400.004	2000.004	400.004
MSD-06-3 TOT ROUND-1	2000.000	400.00<	400.004	400.000	2000.000	400.000	460.004	400.004	2000.000	400.00<
MSD-06-4 TOT ROUND-1	2000.00<	400.094	400.004	400.000	2000.000	400.000	400.004	400.000	2000.0 <b>0</b> <	400.000
MSC-07-1 TOT ROUND-1	2000.004	300.004	300.00<	300.00(	2000.004	<b>30</b> 0.00(	300.00(	300.000	2000.0 <b>0</b> <	300.00<
MSO-07-2 TOT ROUND-1	2000.00<	400.004	400.00<	400.004	2000.00(	400.004	400.004	400.004	2000.000	400.00(
MSC-07-3 TOT ROUND-1	2000.00(	400.00<	400.00<	400.004	2000.604	400.004	400.00<	400.000	2000.0 <b>0</b> 4	400.004
MSO-07-4 TOT ROUND-1	2000.00{	400.004	400.004	400.004	2000.0 <b>0</b> <	<b>40</b> 0.000	400.000	400.004	2000.00{	<b>400.0</b> 04
MSO-07-5 TOT ROUND-1	2000.000	400.00<	400.004	400.00(	2000.000	400.000	400.00{	400.004	2000.000	400.004
MSD-07-6 TOT ROUND-1	2000.004	400.00<	400.004	400.000	2000.000	400.004	400.00<	400.004	2000.00{	400.000
MSD-07-7 TOT ROUND-1	2000.00<	400.00N	400.004	400.00{	2000.00	400.00N	400.00N	400.00<	2000.00(	400.000
MSO-08-1 TOT ROUND-1	2000.004	500.000	500.004	500.000	2000.004	<b>50</b> 0.000	500.00(	500.00<	2000.000	500.00(
MSD-08-2 TOT ROUND-1	2000.00{	400.004	400.00{	400.004	2000.000	400.000	400.00<	400.004	2000.004	400.004
MSO-08-3 TOT ROUND-1	2000.004	500.00{	500.004	500.004	2000.000	500.004	500.000	500.004	2000.004	500.004
MSD-08-4 TOT ROUND-1	2000.00(	400.00<	400.004	400.000	2000.00<	400.000	400.004	400.004	2000.004	400.00(
MSO-09-1 TOT ROUND-1	4000.00<	B00.00<	800.004	800.000	4000.00<	B00.00(	800.004	B00.00(	4000.00<	800.004
MSO-09-2 TOT ROUND-1	2000.000	400.00<	400.004	400.00<	2000.000	400.000	400.004	400.004	2000.004	400.00(
MSD-09-3 TOT ROUND-1	2000.00N	500.00N	500.00N	500.00N	2000.004	500.00N	500.00N	500.0 <b>0</b> N	2000.00<	500.00N
MSD-09-4 TOT ROUND-1	2000.004	500.0 <b>0</b> <	500.004	500.00(	2000.004	500.004	<b>500.00</b> (	500.004	2000.000	500.00(
MSD-09-5 TOT ROUND-1	2000.000	400.000	400.004	400.000	- 2000.000	400.00(	400.004	400.000	2000.004	400,000
MSD-09-6 TOT ROUND-1	2000.00<	400.004	400.000	400.000	2000.004	400.000	400.000	400.00	2000.000	400.000
MSO-09-7 TOT ROUND-1	2000.004	400.004	400.000	400.00<	2000.00<	400.000	400.00(	400.000	2000.00<	400.004
MSD-09-B TOT ROUMD-1	2000.00{	400.000	400.004	400.000	2000.00<	400.000	400.004	400.00<	2000.00<	400.004
MSD-10-0 TOT ROUND-1	3000.000	500.004	500.00<	500.000	3000.004	500.00(	500.000	500.004	3000.000	500.000
NSO-10-1 TOT ROUND-1	2000.00(	500.00(	500.004	500.000	2000.000	500.000	500.000	500.004	2000.000	500.00(
MSO-10-2 TOT ROUND-1	2000.00N	400.00M	460.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	2006.00N	400.00N
MSB-10-3 TOT ROUND-1	2000.000	400.00<	400.000	460.004	2000.004	400.000	400.004	400.004	2000.004	400.000
MSO-10-4 TOT ROUND-1	16000.004	2000.004	2000.00(	2000.000	10000.007	2000.000	2000.000	2000.000	10000.000	2000.000
MSO-11-1 TOT ROUND-1	2000.00(	400.004	400.000	400.000	2000.000	400.000	400.000	400.000	2000.000	400.60<
MSD-11-2 TOT ANUND-1	2000.000	400.000	400.004	400.004	2000.000	400.000	400.000	400.000	2000.000	400.00K
MSD-11-3 TOT ROUND-1	2000.004	400.004	<b>40</b> 0.000	400.004	2000.000	460.000	100.000	400.000	2000.000	400.004

MARINE SEDIMENT SAMPLES - ASARCD SEMI-VOLATILES (ACIDS)

	l Event	Benzoic Acid ppb	2-Chloro phenal ppb	2,4-Di chloro phenol ppb	2,4-Bi methyl phenol ppb	2,4-Bi nitro ,phenol ppb	2-Methyl phenal ppb	4-Methyl phenol ppb	2-Nitro phenol ppb	4-Nitro phenol ppb	4-Chloro- 3-methyl phenol ppb
MSO-11-4 TO	T ROUND-1	2000.00{	500.00<	500.004	500.00(	2000.00(	500.004	500.004	500.00(	2000.00{	500.004
MSO-11-5 TO		2000.004	400.064	400.00(	400.000	2000.004	400.00<	400.000	400.000	2000.000	400.004
MSO-11-6 TO	T ROUND-1	2000.00(	500.004	500.00<	500.004	2000.004	500.000	500.00<	500.00{	2000.000	500.00{
MS0-11-7 TO	T ROUND-1	2000.00(	400.000	400.000	400.000	2000.00(	400.000	400.000	400.00<	2000.00(	400.000
MSD-11-8 TO	T ROUND-1	2000.00<	400.66	400.00{	400.004	2000.000	460.000	400.000	400.000	2000.00(	400.00{
MSD-11-9 TO	T ROUND-1	2000.004	400.000	400.000	400.004	2000.004	400.004	400.00(	400.000	2000.000	400.004
MSD-12-1 TD	round-1	3000.000	500.00(	500.004	500.00(	3000.00<	500,004	500.000	500.004	3000.000	500.004
MSG-12-2 TO	ROUND-1	2000.004	400.00(	400.004	400.004	2000.004	400.000	400.004	400.004	2000.004	400.000
MS0-12-3 TO	F ROUND-1	2000.004	500.00<	500.000	500.00(	2000.00{	500.000	500.000	500.004	2000.00(	500.000
MSD-12-4 TO	ROUND-1	2000.004	400.000	400.004	400.00(	2000.004	400.000	400.000	400.004	2000.00{	400.004
HS0-12-5 TO	ROUND-1	2000.000	400.00<	400.000	400.00(	2000.000	400.000	400.000	400.00(	2000.000	409.000
MS0-13-1 TO	F ROUND-1	2000.004	400.000	400.064	400.000	2000.000	400.000	400.004	400.004	2000.000	400,000
MSD-13-2 TO	round-1	2000.004	400.000	400.000	400.000	2000.004	400.004	400.004	400.004	2000.004	400.00
MS0-13-3 TO	F ROUND-1	2000.004	400.004	400.000	400.004	2000.000	400.000	400.000	400.604	2000.000	400.004
NS0-13-4 TO	F ROUND-1	2000.004	400.004	400.000	400.000	2000.000	400.000	400.00(	400.004	2006.004	400.000
MSD-13-5 TO		2000.00(	400.00<	400.000	400.004	2000.004	400.004	400.000	400.004	2000.000	400.000
MSD-13-6 TO		2000.00(	460.004	400.000	400.004	2000.000	400.000	400.000	400.600	2000.000	400.004
MSD-13-7 TO		2060.004	400.004	400.000	400.004	2000.000	400.000	400.000	400.000	2000.000	400.000
MS0-13-8 TO		2000.004	400.004	400.004	400.000	2000.004	406.004	400.004	400.004	2000.004	400.000
MSO-14-1 TO		3000.000	500.004	500.000	500.004	3000.000	500.00(	500.000	500.000	3000.004	500.000
MSD-14-2 TO		2000.004	400.004	400.000	400.064	2000.00(	400.00(	400.004	400.004	2000.004	400.000
MSO-14-3 TO		2000.00(	500.00N	500.000	500.004	2000.00{	500.06N	500.00N	500.000	2000.004	500.684
MS0-14-4 TO		2000.000	400.004	400.000	400.000	2000.000	400.000	400.000	400.000	2000.004	400.004
MSO-14-5 TO		2000.000		500,000	500.004	2000.000	500,000	500.000	500.004	2000.004	500.000
MSG-15-2 TD		2000.000	400.000	460.004	400.000	2000.000	400.000	400.004	400.000	2000.000	400.000
MS0-15-3 TE		2000.000	400.000	400.000	400.004	2000.000	400.00.	400.000	400.000	2000.000	400.000
MSG-15-4 TO		2000.030	400.000	400,000	400.600	2000.004	400.000	400.060	400.000	2000.004	400.000
MSO-15-5 TO		2000.004	400.004	400.030	400.000	2000.000	460.000	400.000	400.000	2000.000	400.000
MSG-16-1 TO		2000.600	500.004	590.000	500.004	2000.000	500.000	560.000	500.000	2000.000	<b>5</b> 00.60(
MSD-16-2 TD		2000.00<	400.00(	406.06t	400.000	2006.06(	400.000	400.000	400.000	2000.000	400.000
HSD-15-3 TO		2000.00(	400.004	400.00(	400.060	2000.004	400.00%	400.004	100.004	2000.004	400.004
MSC-16-4 70		2000.004	400.064	400.00(	406.000	2000.004	400.001	400.00	100.064	2000.00(	400.600

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

			Benzoic	2-Chloro	2,4-Di chlaro	2,4-Di methyl	2,4-Di nitro	2-Methyi	4-Methyl	2-Nitro	4-Hitro	4-Chloro- 3-methyl
			Acid	phenol	phenol	phenol	phenol	phenol	phenol	phenol	phénol	phenal
Sta 1d	Anl	Event	ppb	ppb	ppb	ppb	ppb	£ pb	ppb	ppb	ppb	ppb
NS0-17-1	TOT	ROUND-1	4000.00<	B00.00<	800.000	800.004	7000.004	800.00<	800.004	B00.00K	9000.000	<b>60</b> 0.00K
MSO-17-2	TOT	ROUND-1	2000.00<	500.00<	500.004	500.00{	2000.000	500.00<	500.000	500.000	2000.000	500.004
MSD-17-3	TOT	ROUND-1	2000.000	400.00(	400.00(	400.00<	2000.00<	400.000	400.000	400.000	2000.000	400.004
MSD-17-4	101	ROUND-1	2000.00<	500.00(	500.004	500.00{	2000.000	500.00(	500.000	<b>50</b> 0.00<	2000.000	500.00(
#SD-18-1	TOT	ROUND-1	4000.004	600.004	800.004	B00.00<	4000.00(	B00.00(	800.000	300.00K	4000.000	800.00(
MSD-18-2	101	ROUND-1	2000.00{	500.00(	500.00(	500.004	2000.00{	500.004	500.004	500.004	2000.000	500.004
MSO-18-3	TOT	ROUND-1	2000.004	400.00<	400.000	400.004	2000.00(	400.960	400.004	400.00<	2000.004	400.00(
MS0-19-1	TOT	ROUND-1	3000.00<	400.00<	400.000	600.004	3000.000	\$00.00<	400.000	600.00<	3000.000	£00.00(
MSO-19-2	TOT	ROUND-1	2000.000	500.00	500.00(	500.00(	2000.00<	500.00	500.000	500.004	2000.00(	500.004
MSO-20-1	TOT	ROUND-1	2000.000	500.00(	500.000	500.604	2000.00(	500.000	500.004	500.000	2000.000	500.00{
MS8-20-2	TOT	ROUND-1	2000.000	500.00(	500.000	500.00(	2000.004	500.004	500.000	500.00(	2000.000	500.000
MSD-21-1	TOT	ROUND-1	3000.000	<b>50</b> 0.00(	500.004	500.004	3000.000	500.004	500.000	500.004	3000.000	<b>50</b> 0.00(
H50-21-2	TOT	ROUND-1	3000.000	800.004	600.004	<b>600.00</b> (	3000.000	400.000	400.000	400.000	3000.004	A00.000
MSD-21-3	TOT	ROUND-1	3000.000	600.004	800.004	400.004	3000.00<	600.00K	600.0CC	600.000	3000.000	400.000
MSO-22-1	TOT	ROUND-1	3000.004	500.000	500.004	500.00(	3000.004	500.004	500.000	500.004	3000.000	500.000
#S0-22-2	TOT	ROUND-1	5000.004	1000.000	1050.000	1000.000	5000.004	1000.00<	1000.000	1000.000	5000.004	1000.004
MS0-22-3	TOT	ROUND-1	3000.004	500.004	500.004	500.000	3000.000	500.000	500.004	500.004	3000.000	500.000
HSD4-0MS	TOT	ROUND-1	1700.00<	2800.00	330.000	330.004	1700.004	330.00(	330.004	330.000	2280.00	2840.00
M507-6M5	TOT	ROUND-1	1700.004	2880.00	330.00(	330.004	1700.000	330.004	330.00<	330.004	2250.00	3110.00
MS07-7KS	101	ROUND-1	1700.000	2560.00	330.000	330.004	1700.004	330.00<	330.004	330.004	1660.00	2390.60
REP-1		ROUND-1	1800.00{	400.004	400.004	400.004	1800.000	400.004	460.000	400.000	1800.000	400,000
REP-2		ROUND-1	2000.004	400.004	400.000	400.004	2000.000	400.000	400.00(	400.000	2000.000	400,003
REP-3		ROUND-1	2000.00(	500.004	500.004	500.000	2000.004	500.000	500.000	500.004	2000.000	500.004
REP-4	TOT	ROUND-1	2000.004	400.004	400.004	400.000	2000.000	400.000	400.004	400.000	2000.004	400,804

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta Id	Anl	Event	Penta chloro phenol ppb	Phenol ppb	2,4,5-Tri chloro phenol ppb	2,4,6-Tri chloro phenol ppb	Biphenyls ppb	Dibenzo thiophene ppb	Dimethyl analine pab	Mathyl phenan thranes ppb	i methyl (2-methyl ethylbenz ppb
METH-10	TOT	ROUND-1	1700.00(	330.00(	1706.004	330.00(	330.00N	330.00N	330.00N	330.0CN	330.00N
HETHOD-1			B30.00(	170.00{	830.000	170.000	170.00N	170.00N	179.00N	170.00N	170.00N
METHOD-7	7 TOT	ROUND-1	1700.00(	330.00<	1700.00N	330.004	330.0CM	330.00N	339.00N	330.00N	330.00N
HETHOD-E	TOT	ROUND-1	1700.00(	330.00(	1700.00(	330.004	330.00N	330.00N	330.00N	330.00N	330,00N
METHOD-9	7OT	ROUKD-1	1700.00(	330.004	1700.004	330.00(	330.00N	330.90M	330.00N	330.00N	330.00N
HS17-1DF	ret (	ROUND-1	3100.00	2600.00	3400.004	860.004	A60.03N	ACO.038	860.03N	460.00N	N60.63A
MS17-1MS	101	ROUND-1	3200.00	2700.00	3400.000	860.000	460.00M	660.00M	660.00M	566.00N	660.00N
MS8-0HSD	707 (	ROUND-1	3320.00	3120.00	1700.000	330.000	330.00N	330.00%	330.00N	330.00N	330.00N
ME7-EHSE	tot c	ROUND-1	2100.00	2060.00	1700.004	330.00<	330.00N	330.00N	330.00M	330.00N	330.00N
MS7-7MSD	101	ROUND-1	2960.00	1860.00	1700.0GN	330.000	330.00N	330.00%	330.00N	330.00N	330.00N
HSD-0-1	TOT	ROUND-1	2000.004	300.004	2000.004	300.00<	300.00N	309.00N	300.66N	300.00N	300.000
MSD-6-2	TOT	RCUND-1	2000.000	560.00	2000.000	400.000	400.00N	400.00N	400.00N	400.00N	400.00N
MS0-0-3	TOT	ROUND-1	2000.00{	1080.60	2000.000	460.000	400.00N	400.00N	400.00N	460.80N	400.00N
MSE-01-1	101	ROUND-1	2000.064	400.000	2000.000	400.000	400.00N	400.00M	400.00M	400.00N	400.00N
MSD-02-1	L TOT	RGUND-1	2000.000	400.000	2000.000	400.000	400.00N	460.00N	400.CGN	400.00N	460.00N
MSC-02-2	101	ROUND-1	3000.000	900.00	3000.000	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
MSD-02-3	101	ROUND-1	2000.00N	400.00<	2000.000	400.000	400.00N	400.00%	400.00N	400.00N	400.00N
MSD-03-1	TOT	ROUND-1	3000.000	400.004	3000.00N	£00.60N	400.00N	400.00M	806.GCN	600.00N	600.00N
MSD-03-2	TOT 2	RJUND-1	2000.00N	400.004	2000.000	400.000	400.00N	400.00N	400.0CM	406.00H	400.00N
MSG-03-3	3 101	ROUND-1	2000.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.GCN
MSD-04-0	101	ROUND-1	3000.00N	500.00N	3000.000	500.606	500.00N	500.00N	500.00N	500.00N	500.000
HS0-04-1	TOT	ROUND-1	2000.00<	400.004	2000.000	400.004	400,00N	400.00N	400.00N	400.00N	400.00N
MEB-04-2	2 TGT	ROUNG-1	2000.00N	400.00N	2000.00N	400.00M	500.00N	560.96W	500.00N	500.00N	500.00N
NSD-04-3	101	ROUND-1	3000.000	500.000	3006.004	500.004	500.00N	500.00m	500.00N	500.00N	500.00N
MSG-65-0	tot (	ROUND-1	2000.000	500.00(	2000.000	500.00<	560.00M	500.00N	500,00N	500.00N	500.00N
MSG-05-1	TOT	ROUND-1	2000.000	400.000	2060.004	400.000	400.00N	400.00M	400.00W	493.00N	406.00N
MSO-65-2	tot s	ROUND-1	2000.00(	400.094	2000.004	400.000	400.00A	400.00X	400.06%	400.00N	460.00N
MSD-05-3			2000.000	400,000	2000.000	400.00(	400.00h	400.00%	400.000	400.00%	400.00N
MSD-06-0	TOT	REUND-1	3000.060	100.000	3000.00(	100.001	£00.00m	409.600	300.66M	500.06N	490.00N
MSD-06-1	TOT	ROUND-1	2000.000	400.0 <b>0</b> K	2000.000	400.000	400.00N	400.00N	430.06N	400.00N	400.00M
<b>₩5</b> 0-06-2	101	ROUND-1	2600.000	400.000	2000.034	409.000	400.00N	400.00%	400,000.	460.00N	400.00N

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

			Penta		2,4,5-Tri	2,4,6-Tri				Mathyl	1 methyl
			chloro		chloro	chloro		Gibenzo	Dimethyl	phenan	(2-methyl
			phenol	Phenol	phenal	phenol	Biphenyls	thiophene	analine	threnes	ethylbenz
Sta Id Ar	nl   	Event	ppb	ρpb	թբե		bbp	bbp	ppb dqq	bbp	pp dqq
MSD-06-3 TI	 DT	ROUND-1	2000.004	400.00<	2000.000	400.004	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-06-4 TO	TG	ROUND-1	2000.00(	400.004	2000.00(	400.000	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-07-1 TI	TO	ROUND-1	2000.00{	300.000	2000.00{	300.000	300.0QN	00.00E	300.00N	300.00N	300.00N
MSD-07-2 TI	GT	ROUND-1	2000.004	400.00(	2000.004	400.004	400.00N	400.00N	400.00N	400.00N	400.00N
MSB-07-3 TI	OŦ	ROUND-1	2000.00(	400.00<	2000.00<	400.00<	400.00N	400.00N	400.00N	400.00N	400.00N
HSD-07-4 TI	10	ROUND-1	2000,004	400.004	2000.004	400.004	400.00N	400.00N	400,00N	400.00N	400.00N
MS0-07-5 Ti	OT	ROUND-1	2000.000	400.00	2000.004	400.004	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-07-6 TI	DT	RDUND-1	2000.00{	400.000	2000.000	400.004	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-07-7 TH	OT	ROUND-1	2000.004	400.00N	2000.00N	400.00<	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-08-1 T	TO	ROUND-1	2000.004	500.00(	2000.004	500.00<	500.00N	500.00N	500.GON	500.00N	500.00N
MS0-68-2 Ti	0T	ROUND-1	2000.000	400.000	2000.064	400.00(	460.00N	400.00N	400.00N	400.00N	400.00N
MSD-08-3 Ti	et	ROUND-1	2000.00{	500.000	2000.004	500.00(	500.0CN	500.00N	500.00N	500.00N	500.00N
MS0-08-4 T	18	ROUND-1	2000.004	4000.000	2000.000	400.000	400.00N	400.00N	400.00N	400.00N	460.00N
MSB-09-1 T	TO	ROUND-1	4000.000	800.000	4000.000	800.004	800.00N	800.00N	800.00N	800.00N	800.00N
MSD-09-2 T	OT	ROUND-1	2000.00(	400.000	2000.000	400.00(	400.00N	400.00N	400.00N	400.00N	400.00N
MS0-09-3 T	TQ	ROUND-1	2000.00(	500.00N	2000.00N	500.000	500.00N	500.0CN	500.00N	500.00N	500.00N
MS0-09-4 T	OT	ROUND-1	2000.000	500.004	2000.00N	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
MED-09-5 T	OT	ROUND-1	2000.00<	400.000	2000.00N	400.000	400.00N	400.00N	400.00N	400.00N	400.00N
MS0-69-6 Ti	DT	ROURD-1	2000.004	400.00<	2000.00{	400.00{	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-09-7 T	OT	ROUND-1	2000.004	400.00(	2000.004	400.000	400.00N	400.0CH	400.00N	400.00N	400.00N
MS0-09-B T	OT	RGUND-1	2000.000	400.000	2000.000	400.664	400.00N	400.00N	400.00N	400.GON	400.00N
MSB-10-6 T	07	ROUND-1	3000.000	500.000	3006.004	500.00(	500.00N	500.00N	500.00N	500.00N	500.00N
MSG-10-1 T	OT	ROUND-1	2000.00<	500.000	2000.00(	500.00(	500.00N	500.00N	500.00N	500.00N	500.0CN
MSO-10-2 T	OT	ROUND-1	2000.00H	400.00N	2000.00N	400.00N	400.00M	400.00N	400.09N	400.00M	400.00N
MSD-10-3 T	GT	ROUND-1	2000.00{	400.000	2000.60(	400.000	400.00N	400.00%	400.00N	400.00N	400.60N
MSO-10-4 T	OT	ROUND-1	10000.000	2000.000	10000.000	2000.000	2000.00N	2000.00W	2000,00%	2000.00N	2000.00N
MSD-11-1 T	ΒT	ROUND-1	2000.000	400.004	2000.000	400.000	400.30N	400.00%	400.00K	400.00N	400.00N
MSD-11-2 T	GT	ROUND-1	2000.004	400.000	2630.000	400.060	400.00N	400.00W	400.00%	400.00N	400.00N
MSO-11-3 T	OT	ROUND-1	2000.000	400.00(	2000.004	400.004	400.00N	400.00R	400.06M	400.00N	400.00N
MSD-11-4 T			2006.00(	500.000	2000.008	500.000	500.00N	500.00N	500.00N	500.00N	500.00N
HSD-11-5 T			2000.004	4000.000	2000.00N	400.000	400.06N		400.00N	400.00N	400.00N
MSO-11-6 T	GT	ROUND-1	2000.000	500.000	2000.004	500.000	500.00N	500.00N	500.00N	500.00N	500.00N

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta 1d		Event	Penta chloro phenol ppb	Phenol ppb	2,4,5-Tri chloro phenol ppb	2,4,6-Tri chloro phenol ppb	Biphenyls ppb	Dibenzo thiopnene ppb	Dimethyl analine ppb	Hethyl phenan threnes ppb	i sethyl (2-methyl ethylbenz ppb
HS9-11-7	701	ROUND-1	2000.004	400.00	2000.004	400.004	400.00N	400.00N	400.00%	400.00N	400.00N
MSO-11-6			2000.004	400.004	2000.00K	400.000	400.00N	400.00%	400.00M	460.00N	400.00N
MSO-11-9	TOT (	ROUND-1	2000.004	400.00(	2000.000	400.000	400.00N	400.00N	400.00N	400.00N	400.00N
MSO-12-1	TOT	ROUND-1	3000.004	500.00(	3000.000	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
MS0-12-2	TOT	ROUND-1	2000.00{	400.00	2000.000	400.000	400.00N	400.00N	400.GON	400.00N	400.00N
HSD-12-3	s tot	ROUND-1	2000.00{	500.0 <b>0</b> <	2000.000	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
MSO-12-4	101	ROUND-1	2000.004	400.000	2000.004	460.004	400.00N	400.00N	460.0CN	400.00N	400.00N
MSO-12-3	T01	ROUND-1	2000.000	400.00{	2000.000	400.000	400.00N	400.00N	400.00N	400.00N	400.00N
NS0-13-1	TOT	RDUND-1	2000.004	400.000	2000.004	400.00{	400.00N	400.00N	400.00N	40G.00N	400.00N
MSD-13-2	TOT S	ROUND-1	2000.000	400.00K	2000.000	400.004	400.00N	400.00V	400.00N	400.00N	400.00N
MSD-13-3	TOT	ROUND-1	2000.004	400.004	2000.000	400.00<	400.00N	400.00N	400.00N	400.00N	400.00N
MS0-13-4	TOT	ROUND-1	2000.004	400.004	2000.000	400.000	400.00N	400.00N	400.00N	400.00N	400.00H
MSD-13-	101	ROUND-1	2000.00(	400.00{	2009.000	400.00K	400.00N	400.00N	400.00N	400.00N	400.00N
MSO-13-6	S TOT	ROUND-1	2000.004	400.000	2000.000	400.00{	400.00N	460.00N	400.00N	400.00N	400.00N
NSB-13-1	7 TOT	ROUND-1	2000.000	400.000	2000.GON	490.000	400.00N	400.00M	400.00N	400.00N	400.00N
MSO-13-1	a TOT	ROUND-1	2000.004	400.000	2000.00N	400.000	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-14-1	TOT	ROUND-1	3000.000	500.004	3000.000	500.00(	500.00N	500.00N	500.00N	500.00N	500.00N
MS0-14-2	TOT S	REUND-1	2000.000	400.004	2000.000	400.000	460.00N	400.00N	400.00N	400.00N	K00.00A
HSO-14-3	3 101	ROUND-1	2000.064	500.00N	2000.000	500.00<	500.00N	500.00N	500.00N	500.00N	500.00N
MS0-14-	TOT P	ROUND-1	2000.00(	400.004	2000.000	400.000	400.00N	400,00N	400.00N	400.00N	400.0GN
MS5-14-5	TOT	ROUND-1	2000.000	500.004	2000.00(	500.064	500.00N	500.00N	500.00N	500.00N	500.00N
MSD-15-1	2 707	ROUND-1	2000.000	400.004	2000.000	400.000	400.00N	400.00N	400.00M	400.00N	400.00N
MSD-15-3	3 TOT	ROUND-1	2000.004	400.000	2000.064	400.00<	400.00N	400.36N	400.00N	400.00N	400.00N
MSD-15-	tot ?	ROUND-1-	2000.000	400.00	2000.000	400,000	400.00N	400.00N	400.00N	400.0CN	400.00N
MSD-15-	TOT 6	ROUND-1	2000.000	400.000	2000.000	400.000	400.00N	406.00N	400.00M	460.00N	400.00N
h:50-16-	1, 161	ROUND-1	2000.004	500.00(	2000.004	500.00(	500.00N	500.00N	500.06N	500.00W	500.00%
MSO-16-	2 101	ROUND-1	2000.004	400.000	2000.000	400.000	400.00N	400,00%	400.00N	400.00%	400.00N
HS0-16-	s tot	ROUND-1	2000.004	400.000	<b>2</b> 000 <b>.</b> 004	400.00(	400.00M	400.00N	400.00N	400.00N	406.00N
MSG-16-	4 TOT	ROUNC-1	2000.004	400.00{	2000.094	490.000	400.00N	400.00%	400.00N	400.00W	400.00%
MSD-17-	TOT i	หิฉับND-1	9000.004	8000.000	4000.000	800.0 <b>0</b> 0	300.00%	600.00N	B00.00M	800.00N	B00.00N
MSQ-17-	z tet	ROUND-1	2000.004	500.000	2000.004	500.000	500.00N	500.00#	500.00%	500.00M	500.00M
KS3-17-	3 101	R0J:10-1	2000.004	400.000	2000.004	400.300	400.00N	400,00h	490.00N	400.00N	400.00M

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

			Penta		2.4,5-Tri	2,4,5-Tri				Methyl	i methyl
			chloro		chloro	chloro		Ditenzo	Dimethyl	phenan	12-methyl
			phanol	Phenol	phenal	phenol	Biphenyls	thiophene	analine	threnss	ethylbenz
Sta id	Anl	Event	apb	ppb	ьbр	pp թ	ppb	ppb		ppb	, ppb
MSD-17-4	TOT	ROUND-1	2000.00<	500.00{	2000.004	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
KSO-18-1	101	RDUND-1	4000.00<	8000.000	4000.00(	800.000	800.00N	800.00N	800.CON	B00.00N	800.00N
MSO-18-2	701	RDUND-1	2000.004	500.00(	2000.000	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
MSO-18-3	TOT	ROUND-1	2000.00{	400.000	2000.00{	400.00<	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-19-1	101	ROUND-1	3000.00<	400.000	3000.000	600.004	600.00N	600.00N	600.00N	600.00N	600.0CN
MSO-19-2	TOT	RGUND-1	2000.00(	500.000	2000.00<	500.004	500.00N	500.00N	500.00N	500.00N	500.00N
MS0-20-1	TOT	ROUND-1	2000.00<	500.00(	2000.004	500.000	500.00N	500.0CM	500.00N	500.00N	500.00M
MEO-20-2	TOT	ROUND-1	2000.00{	500.004	2000.604	500.00<	500.00N	500.00M	500.00N	500.00N	500.00N
MS0-21-1	TOT	ROUND-1	3000.0 <b>0</b> <	500.000	3000.000	500.004	500.00N	500.60N	500.00N	500.00N	500.GON
MS0-21-2	TOT	RGUND-1	3000.00<	400.000	3000.000	600.00	600.00N	600.00N	600.00N	400.00M	600.00N
MSD-21-3	TOT	ROUND-1	3000.00{	600.00	3000.004	600.0 <b>0</b> <	600.00N	600.00N	P00*00M	600.00N	600.00N
MSG-22-1	TOT	ROUND-1	3000.00(	500.00(	3000.000	500.00(	500.00N	500.00N	500.00N	500.00N	500.00N
MSO-22-2	707	ROUND-1	5000.00(	1000.000	5000.00{	1000.000	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N
MSD-22-3	TOT	ROUND-1	3000.004	500.004	3000.000	500.004	500,00N	500.00%	500.00N	500.0GN	500.00N
MSD6-CHS	TOT	ROUND-1	3940.00	2820.00	1700.000	330.004	330.00N	330.00N	330.00%	330.00N	330.00N
HSO7-6HS			2980.00	1790.00	1700.004	330.00<	330.00N	330.00N	330.00N	330.00N	330.00N
MS07-7MS	TOT	ROUND-1	1920,00	2490.00	1700.00N	330.00(	330.00N	330.00N	330.00N	330.00N	330.00N
REP-1	TOT	ROUND-1	1800.004	400.004	1800.000	400.000	400.00{	400.000	400.004	400.000	400.004
REP-2		ROUND-1	2000.004	400.000	2000.000	400.000	400.00N	400.00N	400.00N	460.00N	400.00N
REF-3		ROUND-1	2000.00{	500.004	2000.000	500.064	500.00%	500.00N	500.00N	500.00N	500.00N
REP-4	101	RUUND-1	2000.004	400.000	2000.000	400.000	466.00N	400.00W	400.00N	400.00N	409.00N

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	Ace naphthene ppb	Acenaph thylene ppb	Aniline ppb	Anthracne ppb	Benzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Benzo(b) fluor anthene ppo	Benzo (g,h,i) perylene ppb	Benzo(k) fluor anthene ppb	Benzyl Alcohol ppb	bis(2-ch) oroethoxy )aethane ppb
METH-10	TOT	ROUND-1	330.00<	330.00<	330.00<	330.00<	2700.00(	330.00(	330.004	330.004	330.00<	330.00<	330.00<	330.00(
METHOD-1			170.004	170.004	170.00<	170.00<	1300.00(	170.00<	170.00<	170.00<	170.004	170.004	170.000	170.000
HETHOD-7			330.00<	330.00<	330.000	330.00(	2700.00<	330.00<	330.00<	330.00(	330.00<	330.00<	330.00<	330.000
HETHOD-8	TOT	ROUND-1	330.00<	330.00€	330.00<	330.00<	2700.00<	330.00(	330.00<	330.000	330.00<	330.00{	330.000	330.000
METROD-9	TOT	ROUND-1	330.00<	330.00<	330.00<	330.000	2700.00<	330.00(	330.00<	330.00<	330.00<	330.00{	330.000	330.00(
MS17-1BP	TOT	ROUND-1	1600.00	660.004	160.00	<b>660.00</b> {	5400.00<	460.000	860.00	660.00<	860.00<	100.004	460.000	660.000
HS17-1HS	TOT	ROUND-1	1400.00	460.00<	660.000	660.00	5400.00{	860.000	860.00C	460.000	660.00	\$60.00K	\$60.00K	460.00<
MS6-GMSD	TOT	ROUND-1	1430.00	330.00<	330.00<	330.00<	2700.0 <b>0</b> <	330.00<	330.00<	330.000	330.004	330.00<	330.00(	330.000
HS7-6HSD	TOT	ROUND-1	1100.00	330.00(	330.000	330.00€	2700.00{	330.00<	330,000	330.00(	330.00(	330.00{	330.00(	330.00<
MS7-7MSD	TOT	ROUND-1	1300.00	330.00{	330.00<	330.00{	2700.00(	330.00(	339.004	330.00<	330.00<	330.00<	330.00(	330.00<
MSD-0-1	TOT	ROUND-1	300.00<	300.00{	300.00<	300.00<	3000.00<	300.00<	300.00<	300.00<	300.00<	300.00<	300.004	300.00(
MSD-0-2	TOT	ROUND-1	400.004	400.004	400.000	400.00<	3000.00(	400.00{	400.000	400.00<	400.00<	400.00<	400.000	400.000
MSD-0-3	TOT	ROUND-1	400.00<	400.004	400.004	400.004	3000.00<	400.000	400.004	400.00<	400.000	400.00<	400.004	400.000
MSD-01-1	101	ROUND-1	400.00	400.00<	400.000	400.000	3000.00(	400.000	400.000	400.004	400.004	400.00<	400.004	400.000
MS0-02-1	TOT	ROUND-1	400.00<	400.00<	400.000	400.00<	3000.00<	400.00<	400.00<	400.00{	400.00<	400.00	400.000	400.000
MSD-02-2	TOT	ROUND-1	500.00K	500.004	500.00(	500.00<	4000.00<	500.00(	500.004	500.0 <b>0</b> <	500.004	500.00{	500.00<	500.00<
MSD-02-3	TOT	ROUND-1	400.00{	400.00	400.00<	400.00N	3000.000	400.000	400.00<	400.004	400.00	400.000	400.000	400.000
MSD-03-1	TOT	ROUND-1	400.00N	400.00N	400.000	400.000	4000.00<	400.000	. 500.000	400.000	60û.ÜO<	400.004	400.000	600.00M
MS0-03-2	TOT	ROUND-1	400.004	400.00<	400.000	400.00N	3000.000	400.004	400.000	400.00(	400.00{	400.064	400.00	400.000
MSD-03-3	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	3000.00N	400.GON	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-04-0	TOT	ROUND-1	500.00(	500.004	500.0 <b>0</b> (	400.00J	4000.000	1536.00J	770.003	1500.00J	500.004	500.00(	500.00N	500.00N
MSD-04-1	TOT	ROUND-1	400.000	400.004	400.000	460.00<	3000.00<	400.00(	400.000	400.000	400.000	400.00{	400.000	400.00<
M50-04-2	101	ROUND-1	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-04-3	TOT	ROUND-1	500.004	500.000	500.00(	506.00(	4000.000	500.00<	500.00(	500.00{	500.0 <b>0</b> <	500.00(	500.000	500.00(
MSB-05-0	TOT	ROUND-1	500.004	500.004	500.000	500.09(	4000.000	500.000	500.004	500.00(	500.00(	500.00(	500.000	500.00<
MSD-05-1	TOT	ROUND-1	400.004	400.004	400.000	400.000	3000.00	400.004	400.004	400.000	400.00¢	400.00(	400.000	400.000
MSD-05-2	TOT	ROUND-1	400.00<	400.000	400.000	400.000	3000.000	400.000	400.004	409.000	400.00	400.000	<b>4</b> 00.9 <b>0</b> €	400.000
MSD-05-3			400.00<	400.000	460.000	400.000	3000.000	400.000	400.000	400.000	400.004	400.000	460.00<	400.000
MS0-06-0	TOT	ROUND-1	\$90.00K	Y00.004	400.00<	600.000	5000.000	400.004	400.000	400.004	600.00	400.004	£00.00(	600.000
MSD-06-1			400.004	400.000	400.000	400.0 <b>0</b> €	3000.000	400.004	400.000	406.000	400.000	400.000	400.000	400.000
MSD-06-2	101	ROUND-1	400.000	400.000	400.00{	406.066	3000.000	400.000	400.000	400.000	400.004	400.000	400.064	400.00(
MSD-06-3	TOT	ROUND-1	400.004	400.000	400.604	400.000	3000.00<	400.000	400.00(	400.060	400.000	400.00(	400.000	400.00(

Sta Id	Anl	Event	Ace naphthene ppb	Acenaph thylene ppb	Aniline ppb	Anthracne ppb	Renzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Benzo(b) fluor anthene ppb	Benzo (g,h,i) perylene ppb	Benzo(l.) fluor anthene pab	Benzyl Alcohul ppb	bis(2-chl proethoxy )pethane ppb
MSD-06-4	TOT	ROUND-1	400.00(	400.00<	400.00(	400.004	3000.000	400.064	400.004	400.004	400.004	400.004	400.004	400.000
MSD-07-1	TOT	ROUMB-1	300.00<	300.00{	309.000	300.000	3000.004	300.00<	300,004	300.000	300.00(	300.00(	300.000	300.000
MS0-07-2	TOT	ROUND-1	400.00<	400.004	400.064	400.000	3000.000	400.000	400.00<	400.00(	400.004	400.004	400.000	400.000
KSO-07-3	TOT	ROUND-1	400.004	400.004	400.000	400.000	3000.00(	400.004	400.004	400.004	400.004	400.004	400.004	400.000
MS0-07-4	TOT	RCUND-1	400.00<	400.004	400.004	400.000	3000.00<	400.00<	400.004	400.004	400.004	400.00(	400.004	400.000
MSD-07-5	TOT	ROUND-1	400.000	400.004	400.000	400.00	3000.00<	400.004	400.004	400.00<	400.00<	400.000	400.000	400.000
MSD-07-6	TOT	ROUND-1	400.004	400.004	400.000	400.00<	4000.000	400.00<	400.004	400.000	400.004	400.004	400.000	400.00<
MSD-07-7	TOT	ROUND-1	400.00<	400.004	400.000	400.000	4000.000	400.000	400.000	400.004	400.004	400.004	400.00N	400.000
MSD-08-1	TOT	ROUND-1	500.000	500.000	500.000	500.00(	4000.004	500.000	500.000	500.000	500.000	500.00(	<b>50</b> 0.004	500.00<
MSD-06-2	TOT	ROUND-1	400.00<	400.000	400.000	400.000	3000.00(	400.000	400.000	400.000	400.000	400.004	400.000	400.000
MSD-08-3	TOT	ROUND-1	500.00<	500.004	500.00{	500.004	4000.00<	<b>50</b> 0.00<	500.004	500.00<	500.00(	500.00(	500.004	500.004
MSO-08-4	TOT	ROUND-1	400.00<	400.00<	400.000	400.00<	4000.000	400.000	400.000	400.004	400.000	400.004	400.000	400.00<
MSD-09-1	TOT	ROUND-1	800.00<	4 800.00K	800.000	800.00(	9000,000	800.00	E00.00<	1290.00	860.004	B00.00(	<b>800.0</b> 04	800.004
MSB-09-2	TOT	ROUND-1	400.00<	400.004	400.000	400.060	3000.000	400.00<	400.000	400.00(	400.00<	400.00{	400.064	400.004
MSB-09-3	TOT	ROUND-1	500.000	500.000	500.00(	500.000	4000.000	500.004	500.00<	500.00(	500.000	500.00(	500.00N	500.00N
X50-09-4	TOT	RDUND-1	500.004	500.000	500.00(	500.00<	4000.000	500.00<	500.004	500.000	500.004	500.004	500.000	500.00(
MSD-09-5	TOT	ROUND-1	400.00<	400.000	400.000	460.604	3000.00<	400.000	400.000	400.00(	460.00<	400.000	400.00<	400.000
MSD-09-6	TOT	ROUND-1	400.00<	400.004	400.00<	400.000	3000.000	400.000	400.000	400.00<	400.004	400.00<	400.00(	400.00<
MSO-09-7	TOT	ROUND-1	400.000	400.000	400.004	400.004	3000.000	460.00<	400.000	400.000	400.00<	400.00(	400.094	400.000
MSD-09-8	TOT	ROUND-1	400.00<	400.004	400.000	400.004	3000.000	400.000	400.064	400.000	400.00<	400.00(	400.000	400.00<
MSD-10-0	101	ROUND-1	500.004	500.000	500.00(	500.004	4000.000	830.00	720.00	1640.00	500.004	500.00<	500.000	500.000
MS0-10-1	TOT	ROUND-1	500.000	500.000	<b>50</b> 0.000	500.004	4900.000	500.004	500.00(	530.00	500.00{	500.004	500.004	500.000
MSD-10-2	TOT	ROUND-1	400.00N	400.00N	400.30N	400.00N	3000.00N	400.00N	400.008	400.00N	400.00N	400.00N	400.00N	400.00N
MSO-10-3	TOT	ROUND-1	400.004	400.000	400.904	400.00(	3000.000	400.000	400.000	400.000	400.004	400.000	400.000	400.000
MSD-10-4	101	FOUND-1	2000.000	2000.00(	2000.000	2000.000	20000.00<	2000.000	2000.004	2000.000	2000.000	2000.001	2000.000	2000.000
MSO-11-1	101	round-1	400.00(	400.000	400.000	400.900	4000.000	400.000	460.064	400.000	400.000	400.000	400.00(	400.000
MSD-11-3	TOT	RGUND-1	400.004	400.004	400.004	400.004	3000.004	400.000	400.000	400.000	400.000	400.000	400.00(	400.00<
MSD-11-3	TOT	ROUND-1	409.00	400.00<	400.00<	400.004	3000.004	400.000	400.060	400.000	400.004	400.000	400.00(	400.000
MSD-11-4	TOT	round-1	500.004	500.000	500.064	500.00(	4000.000	500.000	500.004	500.00(	500.000	500.000	500.000	500.000
MSD-11-5	101	ROUND-1	400.000	400.000	400.000	400.000	4000.004	400,090	406.00(	400.000	400.004	400.004	400.004	400.004
MSD-11-6	101	RDSND-1	500.00(	500.000	500.000	500.004	4000.000	<b>5</b> 00.00( )	500.000	500.000	500.004	500.000	500.00(	500.000
MED-11-7	tet	ROUND-1	400.004	400.00(	400.000	400.000	3000.000	400.000	400.000	400.00(	400.004	400.004	400.004	400.004

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	Ace naphthene ppb	Acenaph thylene ppb	Aniline ppb	Anthracne ppb	Benzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Benzo(b) fluor anthene ppb	Benzo (g,h,i) perylene ppb	Benzo(k) fluor anthene ppb	Benzyl Alcahol ppb	bis(2-chl oroethoxy )methane ppb
MSO-11-8	TOT	ROUND-1	400.00	400.004	400.00<	400.00K	4000.00<	400.00	400.00<	400.00{	400.00<	400.00<	400.000	400.000
		ROUND-1	400.004	400.004	400.00{	400.000	4000.004	400.000	400.00<	400.004	400.000	400.004	400.000	400.000
		ROUND-1	500.004	500.004	500.00(	1130.00	4000.000	2250.00	530.00	1300.00	500.004	500.004	500.000	500.0 <b>0</b> K
		ROUND-1	400.00<	400.00<	400.000	400.000	3000.000	400.00<	400.004	400.00<	400.000	400.004	400.000	400.00<
		ROUND-1	500.00<	500.004	500.00<	500.004	4000.000	500.00<	500.00(	500.0 <b>0</b> <	500.004	500.004	500.004	500.000
		ROUND-1	400.004	400.00<	400.000	400.000	3000.004	400.00<	400.00{	400.004	400.000	400.004	400.000	400.000
MS0-12-5	TOT	ROUND-1	400.00<	400.00<	400.000	400.00	3000.00<	400.000	400.000	400.000	400.000	400.00{	400.000	400.000
		ROUND-1	400.004	400.00<	400.000	400.00<	1000.004	1780.00	460.004	400.00{	400.000	400.004	400.000	400.00<
HS0-13-2	TOT	ROUND-1	400.00<	400.00<	400.000	400.00€	3000.000	400.004	400.000	400.00<	400.004	400.00<	400.000	400.000
MSD-13-3	TOT	ROUND-1	400.00<	400.00(	400.00<	400.004	4000.000	400.00(	400.004	400.00	400.00	400.00(	400.000	400.00<
		ROUND-1	400.00<	400.004	400.00	400.00<	3000.000	400.000	400.00(	400.00<	400.004	400.000	400.064	400.000
MSO-13-5	TOT	ROUND-1	400.00<	400.00<	400.00(	400.000	3000.000	400.000	400.004	400.00(	400.000	400.004	400.000	400.000
		ROUND-1	400.00<	400.004	400.004	400.004	3000.000	400.00(	400.003	400.004	400.000	400.000	400.00{	400,000
		ROUND-1	400.00<	400.004	400.00(	400.000	4000.000	400.000	400.00<	400.004	400.000	400.00<	400.000	400.000
MS0-13-8			400.004	400.00<	400.060	400.000	4000.000	400.000	400.00<	400.00(	400.000	400.00<	400.00(	400.0 <b>0</b> 0
		ROUND-1	500.00<	500.00<	500.000	500.000	4000.000	506.000	500.00<	500.0 <b>0</b> <	500.004	500.00(	500.000	500.000
MS0-14-2	TOT	ROUND-1	400.004	400.004	400.000	400.000	4000.000	400.000	400.000	400.00<	400.000	400.004	400.00(	400.000
MS0-14-3	TOT	ROUND-1	500.004	500.004	500.000	500.000	4000.00<	500.00(	500.004	500.000	500.000	500.004	500.00N	500.00(
MSD-14-4	TOT	ROUND-1	400.00{	400.004	400.000	400.00<	4000.000	400.00(	400.000	400.004	400.000	400,604	400.000	400.000
NSO-14-5	TOT	ROUND-1	500.00<	500.00(	500.00(	500.000	4000.000	500.000	500.000	500.00(	560.000	500.004	500.000	500.064
MSD-15-2	TOT	ROUND-1	400.00<	400.004	400.000	400.004	4000.000	400.00(	400.000	400.00<	400.000	400.004	400.004	400.000
MS9-15-3	TOT	ROUND-1	400.004	400.004	400.000	400.004	3000.000	400.00	400.064	400.000	400.000	400.004	400.004	400.00
MSD-15-4	TOT	ROUND-1	400.004	400.00<	400.00K	409.000	4000.000	460.004	400.000	400.0C<	400.000	400.06(	400.000	460.064
MSD-15-5	TOT	ROUND-1	400.00<	400.000	400.000	400.094	3000.000	400.000	400.00{	460.000	400.000	400.000	400.000	400.000
MSD-16-1	TOT	ROUND-1	500.00<	500.000	500.000	500.000	4600.000	500.000	500.000	500.00<	500.064	500.00(	500.004	500.000
MSD-16-2	TOT	ROUNE-1	400.00{	400.004	400.000	400.000	3000.000	400.60<	400.00(	400.00<	400.000	400.000	400.000	400.000
MS0-16-3	TOT	ROUND-1	400.004	400.004	400.000	400.000	4000.000	400.000	400.00(	400.00(	400.000	400.000	400.000	400.000
MS0-16-4	TOT	ROUND-1	400.00<	400.004	400.000	400.000	4000.000	400.000	400.00(	400.000	400.000	400.004	400.000	460.000
MSB-17-1	TOT	ROUND-1	800.004	800.000	800.000	2000.000	16000.000	2500.00	2000.060	2800.00	2000.000	2000.000	<b>2</b> 00.000	800.000
MSD-17-2	tot :	ROUND-1	500.00<	500.00(	500.000	500.00(	4000.000	<b>5</b> 00.000	500.000	500.004	500.000	500.000	500.060	500.000
HSD-17-3	TOT	ROUND-1	400.000	400.000	400.00(	460.000	4600,000	400.00<	400.061	400.004	400.000	400.000	400.060	400.000
MSD-17-4	TOT	ROUND-1	500.004	500.000	500.00(	500.000	4000.000	509.000	500.000	500.004	500.004	500.000	500.000	500.000

MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	An1	Event	Ace naphthene . ppb	Acenaph thylene ppb	Aniline ppb	Anthracne ppb	Benzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Benzolb) fluor anthene ppb	Benzo (g,h,i) perylene ppb	Benzo(k) fluor anthena ppb	Benzyl Alcahol ppb	bis(2-chl oroethoxy )methane ppb
MSD-18-1	TOT	ROUND-1	800.004	B00.604	B00.004	1060.00	7000.000	1810.00	1240.00	2300.00	B00.00(	B00.00<	200.000	B00.004
MSD-18-2	TOT	ROUND-1	500.000	500.00	500.004	500.00(	4000.000	560.00<	500.00(	500.00(	500.000	500.000	500.060	500.00<
MSD-18-3	TOT	ROUND-1	400.00<	400.00(	400.000	400.00<	4000.004	400.004	460.000	400.000	400.000	400.000	400.004	400.0 <b>0</b> (
MSO-19-1	TOT	ROUND-1	600.004	600.000	400.004	600.00(	5000.00<	500.000	400.00<	A00.00K	600.00K	£00.00(	400.000	300.004
MSO-19-2	TOT	RDUND-1	500.00<	500.000	500.000	500.004	4000.000	500.004	<b>500.00</b> (	500.00(	500.004	500.00(	500.004	500.004
MSO-20-1	TOT	ROUND-1	500.004	500.004	500.00(	500.00<	4000.00<	500.000	500.00(	500.00<	500.00(	500.000	500.000	500.00(
MSD-20-2	TOT	ROUND-1	500.00<	500.004	500.004	500.000	4000.00(	500.004	500.004	500.000	500.004	500.000	500.004	500.00(
MSO-21-1	TOT	ROUND-1	500.00(	500.00<	500.00(	740.00	4000.000	1210.00	460.00	1260.00	500.004	<b>500.</b> 000	500.004	500.00(
MSD-21-2	TOT	ROUND-1	600.00(	>00.004	800.00K	600.000	5000.000	200.00	800.000	400.00	400.000	£00.000	600.000	400.00(
MSO-21-3	TOT	ROUND-1	800.00K	400.004	600.000	>00.004	5000.00{	600.000	100.004	400.000	600.00	400.000	600.004	400.00<
MSD-22-1	707	ROUND-1	500.004	500.00<	500.004	500.000	4000.000	500.000	500.00<	570.00	500.000	500.004	500.004	500.000
MSO-22-2	TOT	ROUND-1	1000.000	1000.004	1000.000	1000.00(	B000.00(	1000.00(	1000.000	1000.000	1000.000	1000.004	1000.000	1000.0 <b>0</b> K
MSD-22-3	TOT	ROUND-1	500.004	500.000	500.000	500.004	4000.00<	<b>500.0</b> 0K	500.00(	500.004	500.004	500.004	500.004	500.004
MSG6-0MS	TOT	ROUND-1	1410.00	330.004	330.000	330.00	2700.000	330.000	330.004	330.000	330.004	330.000	330,000	330.00<
MSD7-6MS	101	ROUND-1	3110.00	330.00<	330.00(	330.000	2600.000	330.000	330.00(	330.004	330.00<	330.000	330.060	330.004
MS07-7MS	TOT	ROUND-1	1290.00	330.004	330.004	330.004	2700.00{	330.000	330.004	330.00<	330.00{	330.004	330.000	330.900
REP-1	107	ROUND-1	400.004	400.000	400.000	400.004	3000.00{	400.06<	400.000	400.00<	400.000	400.000	400.000	400.004
REP-2	TOT	ROUNC-1	400.004	400.000	400.000	400.004	4000.000	400.004	400.000	400.004	400.00{	400.000	400.004	400.000
REP-3	TOT	ROUND-1	500.00(	500.000	500.000	500.000	4000.000	500.00(	500.00(	500.000	500.004	500.000	500.000	500.000
REP-4	TOT	ROUND-1	400.00{	400.000	400.000	400.000	3000.000	400.004	400.000	400.00{	400.000	400.00(	400.004	400.000

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	bis(2-ch) proethy)) ether ppb	bis(2-chl oroisopro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Bromoph enyl-phen yl ether ppb	Butyl benzyl phthalate ppb	4-Chloro aniline ppb	2-Chloro naphthlne apb	4-Chlorop henyl phe nyl ether ppb	Chrysene ppb	Dibenzo (a,h) anthracne ppb	Dibenzo furan ppb	1,2- Dicloro Benzene Pab
HETH-10	TOT	ROUND-1	330.00<	330.00<	330.004	330.00(	330.004	330.004	330.00(	330.00<	330.(0(	330.00<	330.00K	330.00<
METHOD-1	TOT	ROUND-1	170.004	170.00<	170.00(	170.00<	170.004	170.000	170.004	170.004	170.000	170.00<	170.000	170.00<
METHOD-7	TOT	ROUND-1	330.00<	330.00<	330.00<	330.000	330.00(	330.000	330.00<	330.00<	330.00<	330.00(	330.00(	330.00(
METHOD-8	TOT	RDUND-1	330.00<	330.00<	330.00<	330.00<	330.00(	330.00<	330.00(	330.00<	330.00<	330.00{	330.00(	330.00(
METHOD-9	TOT	ROUND-1	330.00<	330.00<	330.00<	330.00<	330.00<	330.000	330.00€	330.00{	330.00<	330.00{	330.00<	330.00(
MS17-1DP	TOT	ROUND-1	P90.099	660.00	660.000	460.00	460.000	860.000	660.000	450.000	760.00	660.000	660.00K	660.000
MS17-1MS	TOT	ROUND-1	>00.044	460.00	660.00K	460.00	460.000	460.000	660.000	460.000	760.00	£60.00<	660.00K	660.000
MS6-0MSD	TOT	ROUND-1	330.000	330.00(	330.00<	330.00(	330.00<	330.00(	330.000	330.00(	330.00<	330.00<	330.00<	330.000
MS7-6MSD	TOT	ROUND-1	330.00<	330.00<	330.00<	330.00(	330.000	330.00(	330.000	330.00(	330.00(	330.000	330.00<	330.00(
MS7-7HSD	TOT	ROUND-1	330.00<	330.00<	330.0 <b>0</b> <	330.00<	330.00<	330.000	330.00<	330.00(	330.00<	330.00<	330.00<	330.00<
MSD-0-1	TOT	ROUND-1	300.00<	300.00	300.00<	300.00{	300.00(	300.000	300.00<	300.00{	300.00(	300.00<	300.000	300.00<
MSD-0-2	TOT	ROUND-1	400.000	400.00<	400.00	400.00<	400.00<	400.000	400.00	400.004	400.000	400.00(	400.00<	400.00<
MSD-0-3	101	ROUND-1	400.000	400.00<	400.00<	400.00<	400.000	400.000	400.00{	400.004	400.000	400.000	400.00<	400.000
MSD-01-1	101	ROUND-1	400.00	400.00<	400.00<	400.000	400.00{	400.000	400.00<	400.00<	400.000	400.000	400.000	400.000
MSD-02-1	TOT	ROUND-1	400.00<	400.00<	400,004	400.00<	400.00<	400.000	400.00(	400.00<	400.00(	400.004	400.004	400.000
MS0-02-2	TOT	ROUND-1	500.00<	500.00<	500.000	500.004	500.004	500.004	500.00(	500.00(	500.000	500.000	500.064	500.000
MSO-02-3	TOT	ROUND-1	400.604	400.00<	400.000	400.00N	400.00{	400.064	400.00(	400.060	400.004	400.004	400.000	400.00<
HSD-03-1	TOT	ROUND-1	400.000	٥٥٥.0٥٤	<b>600.00</b> (	800.00	400.000	600.00N	500.00N	600.00N	400.000	400.00(	600.00N	400.00K
MSD-03-2	TOT	ROUND-1	400.00{	400.00<	400.000	400.00N	400.00{	460.000	400.004	400.00{	400.00(	400.00<	400.004	460.000
MS0-03-3	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	400.00N	460.60N	400.00N	400.00N	400.00N	400.0GN	400.00N	400.00N
HSD-04-0	TOT	ROUND-1	500.00N	500.00N	500.00N	500.00N	500.00(	500.00N	500.004	500.00<	2160.00J	500.00(	500.004	560.00N
MSG-04-1	TOT	ROUND-1	400.00<	400.004	460.000	400.000	400.004	400.600	400.000	400.00<	460.004	400.000	400.004	400.000
MSO-04-2	. TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	460.00N	400.00N	400.00N	406.00N
MSD-04-3	TOT	ROUNG-1	500.000	500.00<	500.00<	500.00K	500.00(	500.000	500.064	500.004	500.000	500.004	500.004	500.000
MSB-05-0	101	I-DKUON	500.00{	500.00<	<b>500.0</b> 0K	500.00<	500.000	500.00(	500.000	500.000	500.00(	500.000	500.000	500.000
MS0-05-1	TOT	ROUND-1	406.004	460.000	400.00<	400.004	400.00<	400.00(	400.004	400.064	400.000	400.000	400.004	400.000
MS0-05-2	101	ROUND-1	400.000	400.004	400.004	400.00<	400.000	400.000	400.00(	400.000	400.000	400.000	400.004	400.000
MSD-05-3	TOT	ROUND-1	400.00<	400.000	400.00(	400.00(	400.00(	400.664	400.000	400.000	400.00	400.000	400.004	400.000
MSD-06-0	101	ROUND-1	600.000	£00.00K	£00.06<	600.0 <b>0</b> <	800.000	400.000	\$60,664	600.000	400.000	400.00€	490.000	500.000
MSD-66-1	TOT	ROUND-1	400.004	400.004	400.000	400.660	400.00<	400.000	400.000	400.000	400.000	400.00	400.000	400.000
MSD-06-2	TOT	RGUND-1	400.000	400.000	400.00(	400.000	400.000	400.00(	400.000	400.004	400.004	400.06<	400.00K	400.000
MSD-06-3	TOT	ROUND-1	400.004	400.000	400.600	400.000	400.004	400.000	400.000	400.004	400.000	400.000	400.000	400.00<

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	bis(2-ch) oroethyl) ether ppb	bis(2-chl oroisopro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Bromaph enyl-phen yl ether ppb	Butyl benzyl phthalate ppb	4-Chloro aniline ppb	2-Chloro naphthlne ppb	4-Chlorop henyl phe nyl ether ppb	Chrysene ppb	Dibenzo (a,h) anthracne ppb	Dibenzo furan ppb	1,2- Dicloro tenzene ppb
MSD-06-4	TOT	ROUND-1	400.00(	400.00(	400.000	400.004	400.00(	400.000	400.000	400.00(	400.00(	400.00<	400.004	400.00{
MSB-07-1			300.00(	300.00<	300.004	300.00<	300.000	300.000	300.004	300.004	300.00(	300.00<	300.00	300.000
MSO-07-2	TOT	ROUND-1	400.00<	400.00	400.004	400.000	400.000	400.00{	400.004	400,000	400.000	400.000	400.00(	400.000
MSD-07-3	TOT	ROUND-1	400.004	400.00<	400.00<	400.000	400.00<	400.004	400.004	400.00{	400.004	400.00<	400.000	400.004
MSD-07-4	TOT	ROUND-1	400.00<	400.00<	400.000	400.000	400.00<	400.000	400.00{	400.00{	400.000	400.004	400.00<	400.000
MSD-07-5	101	ROUND-1	400.00<	400.00{	400.004	400.000	400.004	400.00(	400.00<	400.00<	400.000	400.004	400.000	400.004
MSD-07-6	TOT	ROUND-1	400.004	400.00<	400.00<	400.004	400.000	400.00{	400.00<	400.004	400.000	400.004	400.000	400.000
MSD-07-7	TOT	ROUND-1	400.00N	400.00N	400.004	400.00<	400.00<	400.004	400.004	400.00{	400.000	400.00<	<b>40</b> 0.004	400.00N
MS0-08-1	TOT	ROUND-1	500.00<	500.00<	500.00<	500.00<	500.00<	500.00(	500.00(	500.000	500.00(	500.004	500.00<	500.004
MSD-08-2	TOT	RDUND-1	400.00<	400.00{	400.00<	400.00	400.00<	400.000	400.00{	400.004	400.00<	400.00<	400.00<	400.000
MSD-08-3	181	ROUND-1	500.004	500.004	500.004	500.00<	500.00<	500.00(	500.00<	500.00<	500.004	500.00<	500.00(	500.000
MS0-08-4	TOT	ROUND-1	400.00	400.00{	400.004	400.00<	400.00<	400.000	400.00<	400.00<	400.004	400.00<	400.00<	400.000
MSD-09-1	TOT	RDUND-1	B00.00<	B00.00<	800.00	800.00{	800.00<	B00.00<	800.00<	800.004	1290.00	800.00	800.00<	B00.00<
MS0-09-2	TOT	ROUND-1	400.004	400.00<	400.00<	400.00<	400.00<	400.004	400.00{	400.00(	400.00<	400.004	400.004	400.00
MS0-09-3	TOT	ROUND-1	500.00N	500.00N	500.00(	500.00<	500.004	500.00N	500.00<	500.00<	500.004	500.00<	500.00(	500.00N
MSD-09-4	TOT	RDUND-1	500.00<	500.00<	500.000	500.00<	500.00<	500.000	500.004	500.00<	500.004	<b>50</b> 0.00<	500.00(	500.00
HSD-09-5	TOT	ROUND-1	400.00<	400.00<	400.004	400.00<	400.00<	400.00{	400.00{	400.00<	400.004	400.000	400.004	400.00<
MSD-09-6	TOT	ROUND-1	400.00{	400.00<	400.004	400.00(	400.00(	400.00(	400.00{	400.00<	400.000	400.000	400.00<	400.00<
MSD-09-7	TOT	ROUND-1	400.004	400.00<	400.004	400.00{	400.00<	400.004	400.00{	400.00<	400.000	400.000	400.00<	400.000
MSD-09-B	TOT	ROUND-1	400.004	400.00<	400.004	400.00(	400.000	400.004	400.00<	400.004	400.00(	400.00<	400.004	400.004
MSD-10-0	TOT	ROUND-1	500.004	500.00<	2050.00	500.00<	500.00(	500.004	500.00<	500.00(	1800.00	500.00<	500.00(	500.004
MSD-10-1	TOT	ROUND-1	500.00<	500.00<	1660.00	500.00<	500.000	500.004	500.00{	500.00<	530.00	500.00<	500.00(	500.000
MSD-10-2	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	400.0GN	400.00N	400.00N	400.00N	400.00N	400.GON	400.00N	400.00N
MSO-10-3	TOT	ROUND-1	400.00<	400.004	400.00<	400.00	400.00<	400.00<	400.00<	400.00<	400.00<	400.864	400.000	400.000
MSD-10-4			2000.004	2000.00{	2000.00<	2000.00{	2000.00<	2000.000	2000.00<	2000.000	2000.00<	2000.004	2600.00<	2000.000
MSO-11-1	TOT	ROUND-1	400.00<	400.004	400.00<	400.000	400.00<	400.004	400.004	400.00<	400.000	400.00(	400.00(	400.004
MSB-11-2	TOT	ROUND-1	400.00(	400.00<	400.000	400.00(	400.00(	400.00(	400.00(	400.00<	400.004	460.000	400.000	400.004
MSD-11-3			400.00<	400.064	400.004	400.00(	400.000	400.00(	400.000	400.004	400.00	400.004	400.000	400.004
MSD-11-4			500.00<	500.004	<b>500.0</b> 0(	500.000	500.000	500.00(	500.00	500.00<	500.000	500.004	500.004	500.00(
MSD-11-5			400.00<	400.00<	<b>400.</b> 00(	400.00<	400.00<	400.004	400.000	400.004	400.00<	400.06<	400.000	400.000
MSD-11-6			500.00<	500.004	500.000	500.0 <b>0</b> K	500.00	500.00	500.000	500.00<	500.000	500.004	500.00<	500.00
MSO-11-7	TOT	ROUND-1	400.00<	400.004	400.00(	100.004	400.000	400.000	400.00<	400.00<	400.00	400.000	400.00<	400.00(

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	bis(2-chl oroethyl) ether ppb	bis(2-chl oroisopro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Bromaph enyl-phen yl ether ppb	Butyl benzyl phthalate ppb	4-Chloro aniline ppb	2-Chloro naphthlne ppb	4-Chlorop henyl phe nyl ether ppb	Chrysene ppb	Dibenzo (a,h) anthracne ppb	Dibenzo furan ppb	1,2- Dicloro benzene ppb
MSD-11-8	TOT	ROUND-1	400.00<	400.00{	400.00<	400.004	400.004	400.00<	400.00<	400.00	400.00<	400.00<	400.000	400.000
MSD-11-9			400.00{	400.00<	400.00{	400.000	400.000	400.000	400.00<	400.00{	400.00(	400.000	400.000	400.000
MSO-12-1	TOT	ROUND-1	500.004	500.004	500. <b>00</b> <	500.00{	500.004	500.000	500.00(	500.004	2440.00	500.000	500.000	500.064
MSD-12-2	TOT	ROUND-1	400.004	400.000	400.00<	400.00<	400.000	400.00(	400.004	400.004	400.00(	400.000	400.000	400.00{
MSD-12-3	TOT	ROUND-1	500.004	500.00<	500.00<	500.000	500.00K	500.00(	500.00(	500.004	500.00{	500.004	500.000	500.00(
MSD-12-4	TOT	ROUND-1	400.004	400.004	400.00{	400.00(	400.000	400.000	400.00<	400.004	400.004	400.004	400.00<	400.004
MSO-12-5	TOT	ROUND-1	400.00<	400.00<	400.00<	400.00(	400.00(	400.000	400.000	400.004	400,004	400.00(	400.000	400.000
MSD-13-1	TOT	ROUND-1	400.00<	400.00{	400.064	400.00(	400.00(	400.004	400.000	400.000	2210.00	400.00<	400.00<	460.004
MSO-13-2	TOT	ROUND-1	400.000	400.00<	400.00(	400.00	400.00<	400.00(	400.000	400.00{	400.000	400.00<	400.604	400.004
MSD-13-3	TOT	ROUND-1	400.004	400.00{	400.00<	400.00{	400.00<	400.000	400.000	400.000	400.004	400.00<	400.000	400.00<
MSD-13-4	TOT	ROUND-1	400.00<	400.00{	400.000	400.00	400.00<	400.00{	400.00{	400.004	400.004	400.00<	400.00(	400.004
MSD-13-5	TOT	ROUND-1	400.00<	400.00<	400.00<	400.00<	400.00<	400.004	400.000	400.00<	400.004	400.00	400.00<	400.000
MSO-13-6	TOT	ROUND-1	400.004	400.00{	400.00{	400.00(	400.000	400.000	400.000	400.00<	400.00<	400.004	400.004	400.00<
MSD-13-7	TOT	ROUND-1	400.00<	400.00<	400.00<	400.000	400.00<	400.000	400.000	400.604	400.000	400.00	400.000	400.004
MSD-13-8	TOT	ROUND-1	400.00<	400.00<	400.00<	400.000	400.000	400.000	400.000	400.00(	400.00<	400.00<	400.00<	400.004
MS0-14-1	TOT	ROUND-1	500.004	500.004	500.00{	500.00<	500.00<	500.004	500.00	500.00(	500.00(	500.00<	500.00<	500.000
MSD-14-2	TOT	ROUND-1	400.00(	400.00{	400.00{	400.004	400.00(	400.004	400.000	400.00{	400.004	400.00<	400.00(	400.00N
MSD-14-3	TOT	ROUND-1	500.00N	500.00N	500.004	500.000	500.00(	500.004	500.00(	500.00<	500.00(	500.004	500.000	500.0GN
MSD-14-4	TOT	ROUND-1	400.00(	400.00{	400.00{	400.00{	400.00	400.000	400.00<	400.000	400.004	400.004	400.00<	400.000
MS0-14-5	TOT	ROUND-1	500.064	500.00{	500.000	500.00<	500.00(	500.000	500.00<	500.00<	500.004	500.004	500.00(	500.000
MS0-15-2	TOT	ROUND-1	400.00<	400.00(	540.00R	400.00(	460.000	400.000	400.00<	400.000	400,000	400.000	400.00(	400.000
MSD-15-3	TOT	ROUND-1	460.00<	400.00<	740.00R	400.00{	400.00<	400.00(	400.00<	400.004	400.000	400.000	460.00<	10ú.00(
MSD-15-4	TOT	ROUND-1	409.064	400.00	400.000	400.004	400.00<	400.000	400.00	400.00<	400.00	400.004	400.000	400.000
MS0-15-5	TOT	ROUND-1	400.00<	400,000	400.00{	400.000	400.00(	400.66	400.000	400.064	400.004	400.60<	400.000	400.000
MSD-16-1	TOT	ROUND-1	500.00<	500.00<	500.00<	560.00<	500.00(	500.00V	500.000	500.004	500.004	500.000	<b>50</b> 0.604	560.000
MSD-16-2	TOT	round-1	400.004	400.00<	400.000	405.000	400.00<	400.00(	400.664	400.004	400.000	400.000	400.604	400.00(
HSD-16-3	TOT	ROUND-1	400.000	400.00<	400.00<	400.00{	400.00{	400.000	400.06<	400.060	400.00<	400.000	400.00(	400.00(
MSD-16-4	TOT	ROUND-1	<b>40</b> 0.00K	400.00<	400.000	400.000	<b>400.</b> 06(	400.000	400.00{	409.004	490.000	400.00<	400.004	100.300
HS0-17-1	107	ROUND-1	800.00(	800.00<	2000.000	2060.600	2000.00(	600.00K	200.000	2000.064	3100.00	2000.004	800.00(	600.0 <b>0</b> (
MSD-17-2	TOT	ROUND-1	500.000	500,004	500.000	500.000	<b>500.0</b> 0<	500.000	500.000	500.00(	500.004	<b>500.</b> 004	500.004	500.000
MSO-17-3	TOT	rgund-1	400.000	400.000	400.000	400.004	400.06<	400.000	400.000	400.000	400.004	400.00(	400.000	406.064
MSD-17-4	TOT	ROUND-1	<b>500.0</b> 0K	500.000	500.000	500.000	500.000	500,364	500.00<	500.004	500.00(	506.064	500.000	500.000

			bis(2-chl	bis(2-ch)	bis(2-eth	4-Bromoph	Butyl			4-Chlorop		Dibenzo		i,2-
			orcethyl)	oroisopro	ylhexyl)	enyl-phen	benzyl	4-Chloro	2-Chloro	henyl phe		(a,h)	Libenzo	Dictoro
			ether	pyllethar	phthalate	yl ether	phthalate	aniline	naphthlae	nyl ether	Chrysene	anthracae	furan	benzene
Sta Id			ppb	ppb	ppb	ppb	ppb	ppb	ppb	ррв	ppb	ppb	ppb	ppb
MSO-18-1			800.00(		800.004	860.000	800.004	800.000	800.004	B00.00(	2550.00	B00.00(	E00.00K	B00.00(
MS0-18-2	TOT	round-1	500.00<	500.00(	500.000	500.004	500.004	500.000	500.004	500.004	500.004	500.000	500.004	500.004
MSO-18-3	TOT	ROUND-1	400.004	400.00<	400.00{	400.00<	400.000	400.00<	400.004	400.000	400.004	400.00{	400.000	460.000
MSD-19-1	TOT	ROUND-1	800.000	600.00	800.00	600.000	800.00<	400.000	600.00(	200.000	600.00	£00.00(	500.000	800.000
MSD-19-2	TOT	ROUND-1	500.004	500.00(	500.00<	500.000	500.00<	500.00<	500.00(	500.00(	500.004	500.00(	500.000	500.000
MS0-20-1	TOT	ROUND-1	500.004	500.004	500.00(	500.00<	500.000	500.004	500.00(	500.000	500.004	500.000	500.000	500.000
MS0-20-2	TOT	ROUND-1	500.00(	500.004	500.00(	500.00<	500.004	500.00(	500.00(	500.00(	500.004	<b>50</b> 0.000	500.000	500.004
MSO-21-1	TOT	ROUND-1	500.00<	500.000	500.004	500.004	500.00<	500.000	500.004	500.000	2070.00	500.60(	500.004	500.004
MSD-21-2	TOT	ROUND-1	800.00	600.000	600.000	600.000	800.00K	£00.000	600.00<	400.000	600.004	400.00K	400.004	<b>500.00</b> (
MSD-21-3	101	ROUND-1	600.00{	600.00	400.004	600.0 <b>0</b> <	600.000	800.004	600.00	600.000	600.000	400.00	£00.00K	500.00¢
MS0-22-1	TOT	ROUND-1	500.00(	500.004	500.00(	500.00<	500.00<	500.00<	500.004	500.00<	500.00<	500.000	500.00(	500.00<
MS0-22-2	TOT	ROUND-1	1000.004	1000.000	1000.000	1000.000	1000.000	1000.000	1000.004	1000.000	1000.000	1000.004	1000.004	1000.000
MSD-22-3	TOT	ROUND-1	500.004	500.00<	500.000	500.00{	500.00<	500.004	500.00(	500.00<	500.00(	500.004	500.00(	500.004
MSD6-0M9	TOT	ROUND-1	330.004	330.004	330.004	330.004	330.00<	330,004	330.004	330.000	330.0 <b>0</b> (	330.00(	330.00(	330.004
MSD7-&MS	TOT	ROUND-1	330.00<	330.00<	330.000	330.000	330.00<	330.06	330.004	330.00<	330.000	330.000	330.004	336.060
MSD7-7K9	TOT	ROUND-1	330.094	330.004	330.000	330.000	330.000	330.000	330.00<	330.00{	330.00(	330.00<	330.00(	330.000
REP-1	TOT	ROUND-1	400.004	400.00(	400.00(	400.000	400.00(	400.00<	400.000	400.000	400.004	400.004	400.000	406.00{
REP-2	TOT	ROUND-1	400.00<	400.000	400.000	400.00(	400.004	400.000	400.00{	400.000	400.004	400.004	400.004	400.004
REP-3	TOT	ROUND-1	500.00<	500.000	500.00(	500.000	500.000	500.000	500.000	500.000	500.004	500.000	500.00(	500.004
FEP-4	TOT	ROUND-1	400.00(	400.004	400.000	400.000	400.000	400.00(	400.00(	400.004	400.0 <b>0</b> <	400.00{	400.004	400.004

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	1,3- Dichloro benzene ppb	1,4- Dichloro benzene ppb	3,3'- Dichloro benzidine ppb	Diethyl phthalate ppb	Bisethyl phthalate ppb	Di-n- Butyl phthalate ppb	2,4- Dinitro toluene ppb	2,6- Dinitro toluene ppb	Di-n- Octyl Phthalate ppb	Fluor anthene ppb	Fluorene ppb	Hexa chloro benzene pab
HETH-10	TOT	ROUND-1	330.00(	330.00<	670.004	330.00(	330.00<	330.00(	330.000	330.00(	330.00(	330.004	330.06<	330.00(
HETHOD-1			170.004	170.004	330.004	170.000	170.00(	170.000	170.00<	170.004	170.004	170.004	170.000	170.004
METHOD-7			330.004	330.00{	670.004		330.00(	330.000	330.00	330.004	330.00<	330.00(	330.000	330.004
METHOD-8			330.00(	330.00{	470.000	330.000	330.00<	330.00(	330.00(	330.00(	330.00<	330.00<	330.00<	330.004
METHOD-9	TOT	ROUND-1	330.004	330.00<	670.00<	330.00<	330.00<	330.004	330.00<	330.00(	330.00<	330.00(	330.09(	330.00(
MS17-1DP	TOT	ROUND-1	660.00(	1200.00	1300.00(	A60.00<	660.00	460.000	1200.00	A60.00K	660.000	960.00	450.00(	560.000
HS17-1HS	TOT	ROUND-1	660.000	1200.00	1300.00<	660.00	>00.044	460.004	1200.00	660.00k	660.00	1100.00	300.004	££0.00<
MS6-0MSD	TOT	ROUND-1	330.00<	1330.00	660.000	330.00<	330.00<	330.004	1530.00	330.00<	330.00	370.00	330.00<	330.00<
MS7-6MSD	TOT	ROUND-1	330,00<	1160.00	470.00 <b>(</b>	330.00(	330.00<	330.00{	1160.00	330.00<	330.00<	330.00<	330.00(	330.00(
MS7-7HSD	TOT	ROUND-1	400.00	1300.00	470.00<	330.00<	330.00<	330.000	1500.00	330.004	330.00(	330.00(	330.00(	330.000
MS8-0-1	TOT	ROUND-1	300.00(	300.00<	700.00<	300.00<	300.00<	300.004	300.004	300.00(	300.00<	300.00(	300.00<	300.004
MSD-0-2	TOT	ROUND-1	400.00<	400.00{	900.00(	400.00	400.00<	400.00(	400.00<	400.00(	400.00(	400.000	400.004	400.004
MSD-0-3	TOT	ROUND-1	400.000	400.00(	B00.00<	400.000	40û.00<	400.00<	400.004	400.004	400.000	400.004	400.004	400.000
MSD-01-1	TOT	ROUND-1	400.00<	400.004	700.004	400.00{	400.00	400.000	400.000	400.004	400.004	400.00(	400.000	400.000
MSD-02-1	TOT	ROUND-1	400.00(	400.000	800.00<	400.000	400.00<	400.064	400.00{	400.00	400.00<	400.004	400.004	400.000
MSD-02-2	TOT	ROUND-1	500.00(	500.004	1000.00<	500.00(	500.004	500.000	500.004	500.000	500.004	500.00(	500.00	500.00{
MSD-02-3	TOT	RDUND-1	400.00<	400.00<	900.004	400.00<	400.00<	400.00N	400.004	400.00	400.00<	400.00N	400.004	400.00N
MSB-03-1	TOT	ROUND-1	400.00	600.00	1000.00<	7090.00N	MO0.00M	600.000	600.00N	400.00N	400.000	400.00{	400.00N	400.000
MSO-03-2	TOT	ROUND-1	400.00<	400.000	900.00{	400.004	400.00<	400.00N	400.004	400.00{	400.004	400.00N	400.004	400.00N
MSD-03-3	TOT	ROUND-1	400.00N	400.00N	900.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
MSO-04-0	TOT	rgund-1	500.00N	500.00N	1000.000	500.00{	500.00{	500.00N	500.00(	500.000	500.004	2720.00J	500.00<	500.00N
MSD-04-1			400.00<	400.004	700.004	400.000	400.000	400.000	400.000	400.00(	400.00<	400.00<	400.GOK	400.000
MSD-04-2	101	ROUND-1	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-04-3			500.00(	500.004	1000.000	500.004	500.000	500.00	500.000	500.004	500.000	500.00(	500.000	500 <b>.00</b> (
MS0-05-0	TOT	ROUND-1	500.004	500.004	900.000	500.000	500.00<	500.004	500.00<	500.0 <b>0</b> (	500.004	500.004	500.00K	500.000
MSB-05-1	TOT	ROUND-1	<b>40</b> 0.00<	400.00{	700.004	400.000	400.064	400,000	400.000	400.00<	400.00<	400.000	400.004	460.00(
HSG-05-2	TOT	F.OUND-1	490.004	400.000	700.000	400.000	400.00	<b>40</b> 0.000	400.004	400.000	400.000	400.000	400.000	400.000
M50-05-3			400.00{	400.00(	300.00K	<b>40</b> 0.660	400.000	460.600	400.000	400.064	400.000	400.000	400.064	400.064
0-40 <b>-</b> 02M			400.004	600.000	1000.000	400.034	500.004	<b>603.</b> 00K	400.000	£60.0 <b>0</b> (	200.00	£00.00(	600.00<	400.000
MSD-06-1			400.000	400.000	<b>70</b> 0.060	400.000	400,000	400.06%	400.004	400.000	400.004	400.00(	400.000	400.000
MSD-06-2			400.00<	400.00<	800.000	400.000	400.000	400.000	400.064	400.000	400.00(	400.004	400.000	400.000
H20-06-3	TOT	ROUND-1	400.00(	400.00<	BC0.00(	400.064	400.000	4 <b>0</b> 0.060	400.00(	460.000	400.00	400.06	400.000	400.000

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id Anl Event	1,3~ Dichloro benzene ppb	1,4- Dichloro benzene ppb	3,3'- Dichloro benzidine ppb	Diethyl phthalate ppb	Dioethyl phthalate ppb	Di-n- Butyl phthalate ppb	2,4- Dinitro toluene ppb	2,6- Dinitro toluene ppb	Di-n- Octyl Fhthalate ppb	Fluor anthene ppb	Fluorene ppb	Hexa chloro benzene ppb
MSO-06-4 TOT ROUND-1	400.004	400.00{	800.000	400.000	400.004	400.004	400.004	400.000	400.004	400.004	400.004	400.00<
MSO-07-1 TOT ROUND-1	300.004	300.000	700.000	300.000	300.00(	300.000	300.004	300.00(	300.004	300.00<	300.004	300.00(
MSO-07-2 TOT ROUND-1	400.00{	400.00<	700.000	400.00<	400.004	400.000	400.000	400.000	400:004	400.00{	400.000	400.00<
MSD-07-3 TOT ROUND-1	400.00<	400.00<	800.00K	400.000	400.004	400.00:	400.004	400.004	400.004	400.004	400.00<	400.004
MSD-07-4 TOT ROUND-1	400.00{	400.00{	900.00<	400.00<	400.00{	400.00{	400.00<	400.000	400.000	400.00<	400.004	400.004
MSO-07-5 TOT ROUND-1	400.00<	400.00(	B00.00<	400.000	400.004	400.000	400.00<	400.000	400.00<	400.00(	400.000	400.004
MSD-07-6 TDT ROUND-1	400.00(	400.000	900.00<	400.000	400.000	400.00	400.00<	400.000	400.000	400.000	400.004	400.000
MSD-07-7 TOT ROUND-1	400.00N	400.00N	900.00{	490.00J	400.00<	400.064	400.004	400.004	400.004	400.00{	400.000	400.004
MSD-08-1 TOT ROUND-1	500.00<	500.00<	900.00<	3570.00	500.004	500.000	500.00<	500.00{	500.000	500.004	500.000	500.000
MSD-08-2 TOT ROUND-1	400.00<	400.00(	800.00<	400.00<	400.00<	400.004	400.00<	400.004	400.004	400.00(	400.000	400.00(
MSD-08-3 TOT ROUND-1	500.004	500.00{	900.00<	500.00<	500.004	500.00(	500.00<	500.000	500.004	500.064	500.00<	500.004
MSD-08-4 TDT RDUND-1	400.00<	400.000	900.00<	400.00<	400.00<	400.00(	400.004	400.004	400.00<	400.004	400.000	400.000
MSD-09-1 TOT ROUND-1	B00.00(	800.00{	2000.00<	300.004	B00.00<	800.00(	800.00<	800.000	800.004	1850.00	800.000	B00.00(
MSD-09-2 TOT ROUND-1	400.00<	400.00<	800.064	400.004	400.00<	400.00	400.000	400.00<	400.00<	400.004	400.000	400.004
MSD-09-3 TOT ROUND-1	500.00N	500.00N	1000.00	500.004	500.004	500 <b>.0</b> 0<	500.00<	500.004	500.004	500.000	500.00<	500.00<
MSD-09-4 TOT ROUND-1	500.004	500.000	900.00(	500.004	500.00<	500.004	500.004	500.00	500.00<	500.004	500.000	500.00(
MSD-09-5 TOT RDUND-1	400.004	400.00<	800.00(	400.004	400.000	400.000	400.004	400.004	400.000	400.004	400.00<	400.004
MSO-09-6 TOT ROUND-1	400.004	400.004	<b>80</b> 0.00<	400.004	400.00<	400.004	400.00<	400.00{	400.00<	400.000	400.000	400.004
HSD-09-7 TOT ROUND-1	400.004	400.004	800.00(	400.000	400.00<	400.064	460.004	400.00<	400.00<	400.00{	400.000	400.004
MSD-09-8 TOT ROUND-1	400.00{	400.00<	800.00{	400.004	400.004	400.004	400,004	400.004	400.000	400,000	400.000	400.000
MSD-10-0 TOT ROUND-1	500.00<	500.00<	1000.000	500.004	500.00<	500.00<	500.004	500.00(	500.004	4650.00	500.00(	500.00(
MSD-10-1 TOT ROUND-1	500.004	500.000	1000.000	500.00(	500.00(	500.004	500.00<	500.00<	500.00(	B10.00	500.00(	500.004
MSD-10-2 TOT ROUND-1	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
MSO-10-3 TOT ROUND-1	400.004	400.000	800.000	400.00(	400.000	400.00(	400.00<	400.004	400.00(	400.00(	400.00<	400.004
MSD-10-4 TOT ROUND-1	2000.00<	2000.000	4000.000	2000.000	2000.00<	2000.000	2000.004	2000.004	2000.00<	2000.00<	2000.004	2000.000
HED-11-1 TOT ROUND-1	400.00{	400.000	.900.000	400.00<	400.000	400.00(	400.00<	400.000	400.0 <b>0</b> <	560.00	400.00<	400.00<
MSO-11-2 TOT ROUME-1	400.00{	400.004	800.00<	400.004	400.000	400.00(	400.004	400.004	400.000	400.00(	400.000	400.00<
NSD-11-3 TOT ROUND-1	400.00<	400.004	B00.00(	400.000	400.000	400.00(	400.60<	400.000	400.000	400.00(	400.00<	400.000
HSO-11-4 TOT ROUND-1	500.00(	500.004	900.000	500.00€	500.004	500.00(	500.004	500.00(	500.004	500.004	500.000	500.000
MSO-11-5 TOT ROUND-1	400.004	400.00	900.000	400.004	400.000	400.000	400.000	400.000	400.004	400.004	400.00<	400.004
MSO-11-6 TOT ROUND-1	500.00<	500.000	900.000	500.004	500.004	500.000	500.000	500.000	500.000	500.000	500.000	500.00(
MSO-11-7 TOT ROUND-1	400.004	400.004	900.000	400.000	400.000	400.000	400.004	400.00€	400.000	400.000	400.000	400.000

MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	1,3- Dichloro benzene ppb	1,4- Dichloro benzene ppb	3,3'- Bichloro benzidine ppb	Diethyl phthalate ppb	Dimethyl phthalate ppb	Di-n- Butyl phthalate ppb	2,4- Dinitro taluene ppb	7,6- Dinitro toluene ppb	Di-a- Octyl Phthalate ppb	Fluor anthene ppb	Fluorese pps	Hexa chloro benzene ppb
MSO-11-6	TOT	ROUND-1	400.00<	400.00<	900.00(	400.000	400.000	400.004	400.000	400.000	400.001	400.604	400.604	400.000
MSO-11-9	TOT	ROUND-1	400.004	400.000	900.000	400.00<	400.000	400.000	400.000	400.000	400.000	460.064	460.000	400.064
HSD-12-1	101	ROUND-1	500.00<	500.000	1000.000	500.004	500.00(	500.900	500.004	500.00(	500.000	4640.06	500.000	500.00(
MSD-12-2	TOT	ROUND-1	400.00{	400.000	800.000	400.00<	400.00<	570.00R	400.004	400.000	400.000	400.004	400.000	400.000
MSD-12-3	TOT	RGUND-1	500.00{	50ú.00K	900.00(	500.064	500.000	690.00R	500.000	500.000	500.00<	500.000	560.000	500.00<
MSD-12-4	TOT	ROUND-1	400.000	400.00(	B00.00K	400.000	400.00	460.06(	400.004	400.604	400.000	400.000	400.000	409.000
MSO-12-5	TOT	ROUNG-1	400.004	400.00<	900.GDK	400.00{	400.00<	400.00(	400.000	400.000	400.00{	400.000	400.000	400.000
MED-13-1	TOT	ROUND-1	400.004	400.004	800.604	400.000	400.00	400.000	<b>40</b> 0.00(	400.00	400.000	1100.00	400.004	400.004
MSO-13-2	TOT	ROUND-1	400.00<	400.004	800.004	400.000	400.000	400.004	400.000	400.004	400.00<	400.000	400.000	400.00(
MSD-13-3	TOT	RBUND-1	400.004	400.004	900.00	460.000	400.000	460.00(	400.004	400.000	400.0 <b>0</b> <	400.000	400.000	400.00{
NSD-13-4	TOT	ROUND-1	400.00{	400.000	800.000	400.000	400,000	460.004	400.004	400.000	400.000	400.00(	400.00<	400.000
MSO-13-5	TOT	ROUND-1	400.004	400.004	800.000	400.004	400.004	400.060	400.00<	400.00<	400.GO	400.00(	400.000	400.000
MSO-13-6	TOT	ROUND-1	400.000	400.000	800.00(	400.000	400.000	400.000	400.00(	460.000	400.004	400.004	460.004	400.000
MSD-13-7	TOT	ROUND-1	400.004	460.004	900.000	400.004	400.00<	400.000	400.00(	400.000	400.004	400.00<	400.00{	400.00(
MS0-13-8	TOT	round-1	400.004	400.000	900.000	400.00<	400.000	400.00	400.00{	400.000	400.004	400.000	400.004	460.060
MS0-14-1	TOT	KOUND-1	500.00(	500.004	1000.000	500.004	500.00(	500.000	500.00(	500.00(	500.000	920.00	500.000	500.000
MSO-14-2	TOT	ROUNC-1	400.000	400.000	900.000	400.000	400.000	620.00R	400.00<	400.004	400.000	400.000	400.000	400.000
MSO-14-3	TOT	round-1	500.00N	500.00N	900.000	500.000	500.004	770.00E	500.004	500.000	500.000	500,000	500.06(	500.000
HSO-14-4	TOT	ROUND-1	400.000	400.000	900.000	400.000	400.000	400.000	400.000	400.000	400.004	400.000	400.004	400.000
MSD-14-5	TOT	ROUND-1	500.00<	500.00(	500.000	500.000	500.000	500.000	500.000	500.000	500.00(	500.000	500.000	500.000
MSD-15-2			460.000	400.000	900.000	400.060	400.000	766.00R	400.000	400.00<	400.000	400.004	400.000	400.000
MSD-15-3	TOT	ROUND-1	400.000	400.000	800.00	400.00<	400.004	410.00R	400.000	400.000	400.000	400,004	400.000	400.000
MSD-15-4	TOT	ROUND-1	400.00(	400.004	900.060	466.664	400.000	400.000	400.604	400.00(	400.000	400.000	400.000	400.00
MEG-15-5	TOT	ROUND-1	400.000	400.000	860.00¢	400.000	400.000	400.000	400.000	400.000	406.000	400.000	400,060	400.000
MSO-16-1	TOT	ROUND-1	500.004	500.00(	1000.000	500.000	500.000	500.000	500.000	500.000	500.00(	<b>560.0</b> 00	500.000	500.000
MED-18-2	TüT	Füünd-1	400.000	400.000	800.000	400.000	400.064	403.63(	400.000	400.000	400.000	400.00K	405.000	466.000
MSD-16-3	197	FOUND-1	400.090	400.000	930.004	400,000	400.000	<b>400.</b> 001	400.000	400.000	400.060	400.00%	400.000	400.000
MSO-16-4	TGY	ROUND-1	400.000	400.000	900.000	400.000	<b>40</b> 0.000	400.000	400.000	400.00(	400.004	400.00(	400.000	400.000
MSC-17-1	TGT	REUND-1	B60.00K	B00.00K	1000.000	2006.000	800.060	2000.004	300.000	800.000	2000.06	3805.60	2000.000	2000.004
MSD-17-2	TOT	ROUND-1	500.00(	500.000	900.000	500.00(	500.000	<b>500.0</b> 00	500.00K	500.000	300.000	500.000	300.064	500.000
MSD-17-3	TOT	KDUND-1	400.000	400.000	900.00(	400,900	400.000	400.000	400.000	400.000	400.000	400.000	400.000	400.000
MSC-17-4	101	ROUND-1	500.00{	500.060	506.000	500,000	500,000	500.000	300.000	500.000	500.004	<b>50</b> 0.00(	500.000	500.000

			1,3-	1,4-	3,3'-			Di-n-	2,4-	2,6-	Di -n-			Hexa
•			Dichloro	Dichloro	Dichlero	Diethyl	Dimethyl	Eutyi	Dinitro	Dinitro	Octyl	Fluor		phi ara
			benzene	penzene	benzidine	phthalate	phthalate	phthalate	toluene	toluene	Phthalate	anthene	Fluorene	benzene
Sta id	An l	Event	ppb	ppb	ppb	ppb	ррь	apb	ppb	bap	ррь	ppb	ppb	ppb
MS3-1B-1	101	ROUND-1	800.004	800.004	2000.00(	B00.004	B00.004	B00.00(	B00.00K	B00.004	800.004	2670.00	E00.00K	B00.004
M50-18-2	TOT	ROUND-1	500.00(	500.000	900.004	500.000	500.000	500.000	500.004	500.000	500.004	500.00(	500.004	500.004
MSO-18-3	TOT	ROUND-1	400.00{	400.004	900.000	400.09(	400.00	400.000	400.004	400.000	460.004	400.000	400.004	400.004
MSO-19-1	TOT	ROUND-1	600.0 <b>0</b> (	100.004	1000.000	500.000	<b>&amp;00.00</b> <	600.000	600.00	500.00(	600.004	600.000	400.00(	600.00
MSD-19-2	101	ROUND-1	500.00<	500.004	900.004	500.004	500.00K	500.004	500.00(	500.00(	500.00<	500.004	500.000	500.00(
MSD-20-1	TOT	ROUND-1	500.00<	500.000	900.004	500.004	500.00	500.004	500.004	500.004	500.004	500.00(	500.004	500.0 <b>0</b> (
MSD-20-2	101	ROUND-1	500.00{	500.00(	900.000	500.00<	500.000	500.000	500.00(	500.004	500.00<	500.00(	500.000	500.00(
MSO-21-1	TOT	ROUND-1	500.0 <b>0</b> (	500.00(	1000.000	500.000	500.00<	500.064	500.004	500.004	500.00<	3100.00	500.004	500.00(
HS0-21-2	TOT	ROUNG-1	400.00C	600.0 <b>0</b> <	1000.000	600.000	400.00<	400.000	800.000	400.000	400.004	<b>600.</b> 00<	600.000	600.000
MSD-21-3	TOT	ROUND-1	A00.00(	600.00	1000.000	500.064	600.00 <del>&lt;</del>	600.004	600.00<	100.00	£00.00<	600.00	£00.00(	606.004
MS0-22-1	101	ROUND-1	500.00<	500.00<	1000.00<	500.0 <b>0</b> K	500.000	500.06(	500.064	500.00(	500.00<	570.00	500.004	500.00(
MSO-22-2	TOT	ROUND-1	1000.00(	1000.000	2000.000	1000.000	1000.00<	1000.000	1000.00(	1000.000	1000.00(	1100.00	1000.000	1000.0 <b>0</b> 0
MSO-22-3	TOT	ROUND-1	500.004	500.004	1600.000	500.00(	500.004	500.004	500.00(	500.004	500.000	500.00(	500.004	500.000
MSO&-OMS	TOT	ROUND-1	330.004	1190.00	660.00	330.00<	330.00<	330.000	1310.00	330.00(	330.004	890.00	330.00<	330.004
MS87-6MS	TOT	ROUND-1	330.000	1460,00	660.000	330.000	330.064	330.004	1230.00	530.00<	330.00{	330.000	330.000	330.000
1807-7MS	TOT	ROUND-1	330.00<	1260.00	460.000	330.00<	330.000	330.00(	1230.00	330.004	330.004	330.004	330.00(	330.000
REP-1	TOT	ROUND-1	400.004	400.000	700.004	400.004	400.00<	400.004	400.00(	400.004	400.00(	400.004	400.004	400.000
REP-2	TOT	ROUND-1	400.00(	400.004	900.004	400.00<	400.00(	400.004	400.000	400.004	400.00<	400.004	400.004	400.00(
REP-3	TOT	ROUND-1	500.00<	500.004	900.004	500.000	500.004	500.004	500.000	500.00(	500.00<	500.00(	500.000	500.000
REP-4	TOT	ROUND-1	400.000	400.004	700.000	400.004	400.000	400.004	400.00<	400.000	400,004	400.004	400.000	400.0 <b>0</b> (

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	Hexa chloro butadiene ppb	Hexachlor ocyclopen tadiene ppb	Hexa chloro ethane ppb	Indena (1,2,3-cd Pyrene ppb	Iso phorone ppb	2-Hethyl naphthlne ppb	Naphthlne ppb	2-Nitro aniline ppb	3-Nitro aniline ppb	4-Nitro aniline ppb	Nitro benzene ppb	N-Nitrosa diwathyl amine ppb
METH-10	TOT	ROUND-1	330.00{	330.004	330.00(	330.000	330.00(	330.00(	330.00(	1700.00(	1700.004	1700.004	330.00(	330.000
METHOD-1	TOT	ROUND-1	170.000	170.00<	170.00{	170.00<	170.004	170.00(	170.000	830.000	830.00<	B30.00<	170.004	170.000
METHOD-7	TOT	ROUND-1	330.00<	330.00<	330.00{	330.00<	330.00<	330.000	330.00<	1760.004	1700.00<	1700.000	330.00<	330.004
HETHOD-8	TOT	ROUND-1	330.00<	330.00(	330.00<	330.0 <b>0</b> <	330.00<	330.00<	330.00<	1700.004	1700.00(	1700.00(	330.00<	330.00<
HETHOD-9	TOT	ROUND-1	330.00<	330.00<	330.00(	330.00<	330.00(	330.00<	330.004	1700.004	1700.004	1700.00<	330.000	330.000
MS17-1DP	TOT	ROUND-1	860.00	660.00<	660.000	860.000	300.04	\$60.00	460.004	3400.004	3400.004	3400.00(	100.000	500.004
MS17-1MS	TOT	ROUND-1	>00.003	460.004	660.004	460.000	660.00	££0.00<	460.000	3400.00<	3400.00(	3400.004	460.000	660.0 <b>0</b> 0
MS&-CMSD	TOT	ROUND-1	330.00<	330.00(	330.0 <b>0</b> <	330.00(	330.00<	330.00<	330.00<	1700.000	1700.004	1700.00(	330.004	330.00(
MS7-LMSD	TOT	ROUND-1	330.00<	330.004	330.000	330.000	330.00<	330.00(	330.00(	1700.00<	1700.00(	1700.000	330.004	330.000
- MS7-7HSD	TOT	ROUND-1	330,000	330.00<	330.004	330.00<	330.00<	330.00(	330.00(	1700.000	1700.00<	1700.004	330.00<	330.000
MSD-0-1	TOT	ROUND-1	300.00{	300.000	300.000	300.00<	300.00(	300.00(	300.000	2000.004	2000.004	2000.00(	300.00<	300.000
MSD-0-2	TOT	ROUND-1	400.000	400.004	400.064	400.000	400.00{	460.00<	400.06(	2000.00(	2000.000	2000.000	400.004	400.000
HED-0-3	101	ROUND-1	400.00<	400.00<	400.000	400.06<	400.000	400.00<	400.00{	2000.004	2000.00<	2000.00(	400.000	400.000
MSD-01-1	TOT	ROUND-1	400.00<	400.00<	400.00(	400.004	400.06{	400.00(	460.00<	2000.004	2000.00<	2000.000	400.000	400.000
MSD-02-1	TOT	ROUND-1	400.000	400.000	400.000	400.004	400.00{	400.00{	400.000	2000.004	2000.004	2000.00(	400.000	400.00<
MSD-02-2	101	ROUND-1	500.00<	500.004	500.00(	500.00<	500.004	500.00(	500.004	3000.000	3000.000	3000.004	500.000	500.000
MSD-02-3	TOT	ROUND-1	400.00(	400.00<	400.00<	400.00K	400.00<	400.00<	400.000	2000.000	2000.00(	2000.00{	400.000	400.004
MS9-03-1	TOT	ROUND-1	600.00N	600.00N	400.00<	400.000	600.00N	600.00N	£00.00N	3000.00N	3000.00N	3000.00N	600.00N	600.000
MSD-03-2	TOT	ROUND-1	400.000	400.00<	400.000	400.000	400.004	400.000	400.604	2000.000	2000.0 <b>0</b> <	2000.004	400.000	400.004
MSG-03-3	TOT	ROUND-1	400.00N	400.00H	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
MSD-04-0	101	ROUND-1	500.00N	500.004	500.00N	500.004	500.00N	500.00N	500.00N	3000.00{	3000.00(	3000.00(	500.00N	500.004
MS0-04-1	TOT	ROUND-1	400.004	400,004	400.00€	400.000	400.004	400.000	400.004	2000.000	2000.000	2000.000	400.000	400.000
MSD-04-2	TOT	ROUNG-1	400.00N	400.00N	400.00N	460.00N	400.00N	400.00N	400.00N	2000.GON	2000.00N	2000.00N	400.00N	400.0GN
MSD-04-3	TOT	ROUND-1	500.004	500.004	500.00(	500.00<	500.000	500.004	500.00<	3000.000	3000.000	3000.00<	500.004	500.000
MS0-05-0	TOT	ROUND-1	500.00(	500.00(	500.604	500.000	500.00<	500.00(	500.00(	2000.000	2000.004	2000.000	500.990	500.300
HSD-05-1	TOT	ROUND-1	400.000	400.000	400.004	460.0 <b>0</b> €	400.000	490.00€	400.000	2000.000	2000 <b>.00</b> 0	2000.000	400.004	400.004
MSD-05-2			400.004	400.00<	400.000	400.000	400.00<	400.000	400.000	2000.000	2000.000	2000.00	400,000	400.000
MSD-05-3			400.004	400.000	400.004	400.00<	400.000	400.000	460.00(	2000.000	2060.000	2000.00(	400.000	400.000
MSD-06-0			500.000	£00.00<	500.00K	\$00.00<	£00.00(	<b>600.0</b> 04	£00.00<	3000.000	3000.604	3000.00(	400.06	<b>60.00</b> €
MSD-06-1			400.000	400.004	400.000	400.000	400.004	400.000	409,000	2000.300	2000.004	2000.00(	400.00	400.000
MSD-06-2	TOT	ROUND-1	400.00<	400.000	400.00<	400.000	400.004	400.000	400.004	2000.00(	2000.000	2000.004	400.604	400.900
NSD-08-3	TüT	ROUND-1	400.00<	460.000	400.000	400.000	400.064	400.000	400.0 <b>0</b> 0	2000.000	2000.00<	2000.000	400.060	400.000

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	Hexa chloro butadiene ppb	Hexachlor ocyclopen tadiene ppb	Hexa chloro ethane ppb	Indeno (1,2,3-cd Pyrene ppb	Iso phorone ppb	2-Hethyl naphthlne ppb	Naphthlne ppb	2-Nitro aniline ppb	3-Nitro aniline ppb	4-Nitro aniline ppb	Nitro benzene ppb	N-Nitroso dimethyl amine ppb
MSD-06-4	TNT	R011910-1	400.00(	400.004	400.00(	400.00(	400.000	400.00	400.00(	2000.00{	2000.00{	2000.00<	400.00	400.00<
MSD-07-1			300.004	300.00<	300.00<	300.00(	300.00(	300.00(	300.00<	2000.004	2000.00(	2000.00{	300.004	300.00(
MSD-07-2			400.00<	400.004	406.000	400.004	400.00(	400.004	400.00	2000.00(	2000.004	2000.00<	400.000	400.000
MSD-07-3			400.004	400.00(	400.00<	400.004	400.000	400.00(	400.00<	2000.004	2000.00(	2000.00(	400.004	400.00(
MSD-07-4			400.004	400.004	400.00<	400.004	400.000	400.000	400.004	2000.000	2000.00{	2000.00(	400.000	400.000
KSD-07-5			400.00<	400.004	400.004	400.000	400.004	400.004	400.004	2000.004	2000.004	2000.00<	400.000	400.000
MSD-07-6			400.00<	400.004	400.004	400.00<	400.000	400.00<	400.004	2000.004	2000.004	2000.004	400.00<	400.000
MSD-07-7			400.00<	400.004	400.00N	400.004	400.004	400.000	400.00<	2000.004	2600.004	2000.00<	400.004	400.000
MSD-08-1	TOT	ROUND-1	500.004	500.004	500.00<	500.0 <b>0</b> <	500.004	500.004	500.004	2000.004	2000.00<	2000.004	500.00(	500.004
MSD-08-2	101	ROUND-1	400.004	400.000	400.004	400.000	400.004	400.00<	400.00(	2000.004	2000.0Ò(	2000.00<	400.004	400.004
MSB-08-3	TOT	ROUND-1	500.00<	500.004	500.00(	500.00<	500.00{	500.00(	500.004	,2000.004	2000.004	2000.004	500.000	500.00{
MSD-08-4	TOT	RDUND-1	400.00{	400.004	400.000	400.00<	400.00<	400.00(	400.000	2000.004	2000.00{	2000.004	400.004	400.004
MSO-09-1	TOT	ROUND-1	800.00<	B00.00<	800.00(	800.00<	B00.00(	800.004	800.004	4000.000	4000.004	4000.004	800.00<	800.004
MS0-09-2	TOT	ROUND-1	400.00<	400.004	400.004	400.004	400.004	400.00<	400.00(	2000.004	2000.00<	2000.004	400.000	400.00
MSD-09-3	TOT	RDUND-1	500.00N	500.00<	500.00N	500.00{	500.00N	500.00N	500.00N	2000.004	2000.00{	2000.00<	500.00N	500.000
MSD-09-4	TOT	ROUND-1	500.004	500.00<	500.00<	500.004	500.004	500.00{	500.004	2000.00<	2000.00(	2000.004	500.00(	500.004
MSD-09-5	TOT	ROUND-1	400.000	400.004	400.000	400.004	400.000	400.00{	400.00<	2000.00<	2000.004	2000.004	400.004	400.004
NS0-09-6	TOT	ROUND-1	400.00<	400.00{	400.004	400.000	400.00(	400.000	400.00	2000.000	2000.004	2000.004	400.004	400.00<
MSD-09-7	TOT	ROUND-1	400.00<	400.000	400.00<	400.000	400.000	400.004	400.004	2000.00<	2000.004	2000.00<	400.00(	400.00<
MSD-09-8	TOT	ROUND-1	400.000	400.004	400.00<	400.00<	400.004	400.00<	400.00<	2000.00<	2000,004	2000.004	400.004	400.004
MSD-10-0	TOT	ROUND-1	500.00{	500.00<	500.00<	500.000	500.00{	500.000	500.00(	3000.00<	3000.000	3000.00(	500.004	500.000
MSD-10-1	101	ROUND-1	500.00<	500.00<	500.00<	500.00<	500.00<	500.00(	500.004	2000.00{	2000.00{	2000.00<	500.004	500.00{
MSD-10-2	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
MSO-10-3	TOT	ROUND-1	400.00<	400.00<	400.00<	400.00<	400.00<	400.000	400.00{	2000.004	2000.004	2000.004	400.00{	400.004
#SD-10-4	TOT	ROUND-1	2000.00<	2000.000	2000.00(	2000.00<	2000.00<	2000.00{	2000.00<	10000.000	10000.004	10000.000	2000.000	2000.064
MSD-11-1	TOT	RDUND-1	400.00(	400.00(	400.00<	400.000	400.00<	400.000	400.000	2000.004	2000.00<	2000.00(	400.000	400.004
MSO-11-2	TOT	ROUND-1	400.00<	400.00<	400.000	400.000	400.00<	400.000	400.00<	2000.004	2000.00<	2006.004	400.004	400.004
MS9-11-3	TOT	ROUND-1	400.00<	400.00(	400.004	400.00<	400.00<	400.000	400.004	2000.000	2000.00<	2000.000	400.00<	400.00<
MSD-11-4	TOT	ROUND-1	500.004	500,00<	500.00<	500.004	500.004	500.00	500.0 <b>0</b> (	2000.00<	2000.00<	2000.000	500.000	500.00<
MSO-11-5	TOT	ROUND-1	400.000	400.00<	400.00<	400.00{	400.000	400.000	400.000	2000.004	2000.004	2000.000	400.00	400.00<
MSD-11-6	TOT	ROUND-1	500.00<	500.00<	500.00(	500.00<	500.00(	500.004	500.00<	2000.0 <b>0</b> <	2000.004	2000.000	500.004	500.000
MSO-11-7	TOT	ROUND-1	400.00<	400.00<	400.00(	400.00(	400.00(	460.000	400.00<	2000.00<	2000.000	2000.000	400.00<	400.00

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id Ar	nì	Event	Hexa chloro butadiene ppb	Hexachlor ocyclopen tadiene ppb	Hexa chloro ethane ppb	Indeno (1,2,3-cd Pyrene ppb	Iso phorone ppb	2-Methyl naphthlne ppb	Naphthlne ppb	2-Nitro aniline ppb	3-Nitro aniline ppb	4-Nitro aniline ppb	Hitro benzene ppb	N-Nitroso dimethyl amine ppb
MSO-11-8 T(	 กา	ROUND-1	400.00<	400.00{	400.00<	400.004	400.00<	400.004	400.004	2000.00<	2000.00	2000.004	400.00<	400.00<
MSD-11-9 TE			400.00	400.004	400.004	400.00(	400.00<	400.004	400.00<	2000.004	2000.004	2000.004	400.004	400.004
MSO-12-1 TO			500.00	500.00<	500.004	500.00<	500.00<	500.00(	500.00	3000.000	3000.004	3000.004	500.004	500.004
MSO-12-2 TO			400.00(	400.004	400.004	400.004	400.00	400.00	400.004	2000.004	2000.004	2000.00(	400.00<	400.004
MSD-12-3 TE			500.00(	500.004	500.00(	500.00(	500.00{	500.00(	500.004	2000.004	2000.004	2000.00<	500.00<	500.004
MSD-12-4 TE			400.00(	400.00<	400.000	400.004	400.00<	400.000	400.00<	2000.000	2000.000	2000.000	400.000	400.004
MSD-12-5 TO			400.00<	400.004	400.000	400.00(	400.00	400.00<	400.000	2000.004	2000.004	2000.00<	400.004	400.004
HSD-13-1 TO			400.00<	400.00<	400.00<	400.004	400.00{	400.00{	400.00<	2000.00<	2000.00<	2000.00<	400.000	400.004
MSD-13-2 TO	OT	ROUND-1	400.00<	400.00<	400.00<	400,004	400.004	400.00	400.004	2000.00<	2000.00<	2000.00{	400.000	400.004
MSD-13-3 TO	OT	ROUND-1	400.00<	400.00<	400.00<	400.004	400.000	400.00<	400.004	2000.004	2000.00(	2000.004	400.000	400.004
MSB-13-4 TO	OT	ROUND-1	400.004	400.00<	400.000	400.00<	400.00<	400.00<	400.00(	2000.004	2000.000	2000.004	400.00<	400.000
MSD-13-5 TI	DT	ROUND-1	400.00<	400.004	400.00(	400.000	400.00(	400.00<	400.004	2000.004	2000.00{	2000.004	400.00(	400.00<
MSO-13-6 TO	OT	ROUND-1	400.004	400.004	400.00{	400.00(	400.000	400.004	400.00<	2000.00<	2000.00{	2000.000	400.00<	400.004
MSD-13-7 TO	TO	ROUND-1	400.004	400.000	400.00<	400.00<	400.00{	400.000	400.00(	2000.004	2000.000	2000.00(	400.004	400.000
MSO-13-8 TO	ÛŢ	ROUND-1	400.00(	400.00(	400.00<	400.000	400.00(	4001000	400.000	2000.00(	2000.000	2000.00(	400.00(	400.000
MSB-14-1 TO	DT	ROUND-1	500.00<	500.00(	500.G <b>0</b> <	500.000	500.004	500.000	500.000	3000.004	3000.00(	3000.00(	500.000	500.00(
MS8-14-2 TO	OT	ROUND-1	400.00<	400.00{	400.004	400.00<	400.00{	400.00{	400.000	2000.004	2000.0 <b>0</b> (	2000.004	400.00<	400.004
MSD-14-3 TO	CT	ROUND-1	500.00(	500.00(	500.00N	500,000	500.00(	500.000	500.00(	2000.00(	2000.064	2000.00(	500.000	500.000
MSC-14-4 TO	OT	ROUND-1	400.004	400.004	400.000	400.00<	400.004	400.004	400.004	2000.004	2000.000	2000.000	400.00<	400.00(
MSD-14-5 TO	37	ROUND-1	500.00{	500.00<	500.06(	500,004	500.00(	500.000	500.004	2000.000	2000.004	2000.000	500.000	509.000
MSD-15-2 TO	TG	ROUND-1	400.00	400.00<	400.000	400.000	400.00<	400.000	400.000	2000.00(	2000.0 <b>0</b> (	2000.004	400.000	400.000
MSD-15-3 TE	DT	ROUND-1	400.004	400.00<	400.000	400.000	400.00<	400.00<	400.004	2000.000	2000.000	2000.00(	400.000	400.000
MSB-15-4 TE	01	ROUND-1	400.004	400.00(	400.004	400.00<	400.00	400.00<	400.000	2000.004	2000.00<	2000.004	400.004	400.000
MSO-15-5 TO	OT	ROUND-1	400.00<	400.00<	400.004	400.00(	400.00(	400.00<	400.004	2000.000	2000.004	2000.004	400.004	400.00<
MSD-16-1 TO	DT	ROUND-1	500.004	500.004	500.00(	500.004	500.000	500.000	500.00<	2000.000	2000.004	2000.00(	500.00<	500.00<
MSD-16-2 TO	ÐΤ	ROUND-1	400.004	400.004	400.00(	400.000	400.00{	400.004	400.000	2000.00<	2000.004	2000.000	400.000	400.00 <b>&lt;</b>
MSD-16-3 TO			400.00<	400.00(	400.00<	400.0 <b>0</b> (	400.00<	400.00<	400.000	2000.004	2000.000	2000.000	400.000	460.000
MSD-16-4 TO			400.00<	400.00{	400.00<	400.000	400.00(	400.000	400.000	2000.000	2000.004	2000.004	400.000	400.000
MSO-17-1 TO			800.004	B00.00(	B00.00K	2000,000	800.004	<b>8</b> 00.000	800.00<	4000.000	4000.000	9000,004	800.000	900.000
MSD-17-2 TO			500.0 <b>0</b> <	500.00(	500.00(	500.000	500.00(	500.004	560.000	2000.004	2000.000	2000.000	500,000	500.000
MSO-17-3 TO			400.004	400.00<	400.00(	400.00(-	400.00(	<b>40</b> 0.00<	400.000	2000,000	2000.000	2000.004	400.000	400.000
MSD-17-4 TC	BT	ROUND-1	500.00<	500.004	500.000	500.00(	500.000	500.00<	500.000	2000.000	2000.004	2000.000	500.004	500.004

			Hexa	Hexachlor	Hexa	ladeno								H-Nitroso
			chlora	ocyclopen	chlore	(1,2,3-cd	lso	2-Methyl		2-Nitro	3-Nitro	4-Nitro	Mitro	disethyl
			butadiene	tadiene	ethane	Pyrene	phorone	naphthlne	Kaphthlne	aniline	aniline	aniline	benzene	anine
Sta Id	Anl	Event	ррь	ppb	bbp	ppb	ppb	ppb	ppb	ppb	ppb	ppb p	рръ	ppb
#S0-18-1	TOT	RCUND-1	B00.00<	800.004	B00.00(	B00.00K	800.000	800.000	800.000	4000.004	4000.000	/4000.00 <b>(</b>	B00.00K	BC0.00K
MSD-18-2	TOT	ROUND-1	500.000	500.00(	500.00{	500.004	500.004	500.000	500.00(	2000.000	2000.00<	2000.000	500.000	500.000
KSO-18-3	TOT	ROUND-1	400.004	400.000	400.004	400.000	400.00(	400.000	400.004	2000.000	2000.000	2000.000	400.000	400.004
MSO-19-1	TOT	ROUND-1	400.00K	400.00	600.000	600.000	400.000	800.00C	<b>600.00</b> K	3000.004	3000.000	3000.004	400.00(	400.000
MSD-19-2	TOT	ROUND-1	500.004	500.00{	500.000	500.004	500.00(	500.000	500.00<	2000.000	2000.000	2000.00<	500.004	500.004
MSD-20-1	TOT	ROUND-1	500.004	500.00<	500.00(	500.004	<b>50</b> 0.00(	500.000	500.00(	2000.000	2000.0 <b>0</b> (	2000.00(	500.000	500.004
MSB-20-2	TOT	ROUND-1	500.00{	500.004	500.00(	500.004	500.00<	500.000	500.004	2000.000	2000.004	2000.000	500.004	500.00(
MS8-21-1	TOT	ROUND-1	500.00<	500.004	<b>500.0</b> 04	500.000	500.00{	500.004	500.000	3000.000	3000.000	3000.000	500.00(	500.000
MS8-21-2	TOT	ROUND-1	600.00	400.000	400.000	600.000	800.004	600.000	800.00K	3000.000	3000.000	3000.000	400.004	600.000
MSG-21-3	TOT	ROUND-1	600.000	600.000	600.000	600.00	400.00	800.000	60.00	3000.000	3000.004	3000.00(	100.004	900.004
MSB-22-1	TOT	ROUND-1	500.004	500.00<	500.00(	500.000	500.00{	500.000	500.00<	3000.000	3000.000	3000.000	500.00(	500.004
MS0-22-2	TOT	ROUND-1	1000.000	1000.004	1000.00(	1000.004	1000.00(	1000.00<	1000.000	5000.000	5000.004	5000.00<	1000.000	1000.000
MSO-22-3	TOT	ROUND-1	500.004	500.000	500.00(	500.004	500.00(	500.000	500.000	3000.00<	3000.000	3000.00<	500.00(	500.000
MSD4-0MS	TOT	round-1	330.000	330.06<	330.00(	330.064	330.00(	330.000	330.000	1700.004	1700.000	1700.00K	330.000	330.000
MSD7-5MS	TOT	RGUND-1	330.00(	330.000	330.000	330.004	330.00<	330,000	330.00<	1700.000	1700.004	1700.000	330.064	330.000
MSD7-7MS	TOT	ROUND-1	330.00<	330.004	330.000	330.000	330.000	330.000	330.000	1700.000	1700.00(	1700.000	330.00(	330.000
REP-1	TOT	ROUND-1	400.004	400.000	400.000	400.000	400.004	400.000	400.000	1800.004	1800.004	1800.000	400.000	460.000
REP-2	TST	ROUND-1	400.004	400.00<	400.000	400.000	400.000	400.00K	400.00<	2000.000	2000.000	2000.000	460.60<	400.000
REP-3	TOT	ROUND-1	500.00<	500.004	500.004	500.004	500.004	500.00(	500.004	2000.09(	2000.000	2000.00<	500.060	500.004
REP-4	101	RDUND-1	400.004	400.004	400.00<	400.004	400.00<	400.000	400.004	2000.00(	2000.004	2000.004	400.00{	400.004

MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	N-Hitroso dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Phen anthrene ppb	Pyrene ppb	1,2,4-Tri chloro benzene ppb
METH-10	TOT	ROUND-1	330.004	330.00<	330.00(	330.00(	330.00<
METHOD-1	TOT	ROUND-1	170.004	170.00<	170.004	170.004	170.00<
HETHOD-7	TOT	ROUND-1	336.004	330.00<	330.00(	330.000	330.00<
8-DOHT3M	TOT	ROUND-1	330.00<	330.00<	330.00<	330.00(	330.000
METHOD-9	TOT	ROUND-1	330.00<	330.00<	330.00(	330.004	330.00(
MS17-1DP	TOT	ROUND-1	1300.00	990.094	1000.00	3300.00	1100.00
MS17-1MS	TOT	ROUND-1	1300.00	660.000	1200.00	3400.00	1200.00
MSA-OHSD	TOT	ROUND-1	1460.00	330.00<	330.00<	1490.00	1290.00
MS7-6MSD	TOT	ROUND-1	1030.00	330.0 <b>0</b> <	330.00	1100.00	1130.00
MS7-7KSD	TOT	ROUND-1	1530.00	330.00<	330.0 <b>0</b> (	1500.00	1360.00
MSB-0-1	TOT	ROUND-1	300.00<	300.004	300.00(	300.00<	300.00<
MSQ-0-2	TOT	ROUND-1	400.00<	400.004	400.004	400.0Ö(	400.004
KS0-0-3	TOT	ROUND-1	400.00<	400.00<	400.00(	400.000	400.00(
MSD-01-1	TOT	RCUND-1	400.00<	400.0 <b>0</b> <	400.004	400.004	400.00<
MS0-02-1	TOT	ROUND-1	400.00<	400.004	400.000	400.00{	400.00<
MSD-02-2	TOT	ROUND-1	500.004	500.004	500.004	500.004	500.00{
MSD-02-3	TOT	ROUND-1	400.004	400.00N	400.00N	400.000	400.00<
MSB-03-1	TOT	ROUND-1	400.004	600.004	400.00(	400.000	600.00N
MSB-03-2	TOT	ROUND-1	400.00<	400.00N	400.00N	400.00<	400.00<
MSO-03-3	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	400.00N
MSD-04-0	TOT	ROUND-1	500.00N	500.00N	1B30.00J	3470.00J	500.00N
HSD-04-1	TOT	ROUND-1	400.004	400.004	400.000	400.000	490.00<
MSD-04-2			400.CON	400.00N	400.00N	400.00N	400.00N
MS0-04-3			500.00<	500.00<	500.004	500.000	500.004
KS0-05-0	TOT	ROUND-1	500.004	500.004	500.00(	500.00(	500.00(
MSC-05-1			400.064	400.00<	400.00	400.000	400,004
#SD-05-2	TOT	ROUND-1	400.004	400.000	400.000	400.000	460.000
KSD-05-3	TOT	ROUND-1	400.004	400.000	400.004	406.00(	409.000
MSB-04-0			800.00K	400.000	400.000	£00.00(	400.000
1-30-02N			400.004	400.000	400.000	400.000	400.000
MSD-06-2			400.000	400.000	400.000	400.00(	400.000
FSD-08-3	101	ROUND-1	460.604	400.00<	400.004	400.000	400.004

MARINE SEDIMENT SAMPLES - (BASE MEUTRALS)

Sta Id	Anl	Event	N-Nitrosa dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Phén anthrene ppb	Pyrene ppb	1,2,4-Tri chloro banzene ppb
MSD-06-4	TOT	ROUND-1	400.004	400.004	400.004	400.004	400.00(
MSD-07-1			300.004	300.004	300.004	300.000	300.00<
HSD-07-2	TOT	ROUND-1	400.004	400.004	400.004	400.000	400.00<
MSD-07-3	TOT	ROUND-1	400.00<	400.004	400.004	400.000	400.000
MSB-07-4	TOT	ROUND-1	400.004	400.004	400.004	400.000	400.00<
MSD-07-5	TOT	RDUND-1	400.004	400.004	400.004	400.000	400.000
MED-07-6	TOT	ROUND-1	400.004	400.00{	400.004	400.004	400.00{
MSO-07-7	TOT	ROUND-1	400.00N	400.000	400.004	400.000	400.00(
MSD-08-1	TOT	ROUND-1	500.004	500.004	500.004	500.000	500.000
MSD-08-2	TOT	ROUND-1	400.604	400.004	400.004	400.0CM	400.004
MSD-08-3	TOT	ROUND-1	500.00<	500.004	500.00(	500.00K	500.00<
MS0-08-4	TOT	ROUND-1	400.000	400.00(	400.000	400.004	400.00<
MSD-09-1	TOT	ROUND-1	800.00(	800.004	8B0.00	2020.00	800.000
MSO-09-2	101	ROUND-1	400.004	400.004	400.004	400.000	400.000
NS0-09-3	TOT	ROUNE-1	500.00N	500.00{	500.004	500.000	500.00N
MSD-09-4	TOT	ROUND-1	500.004	500.00<	500.00(	500.004	500.004
MSD-09-5	TOT	ROUND-1	400.00(	400.004	400.004	406.000	400.00<
MSO-09-6	iot	ROUND-1	400.004	400.00(	400.00(	400.000	400.00{
KS0-09-7	TOT	ROUND-1	400.004	400.004	400.000	400.00<	400.004
MSG-09-8	TOT	ROUND-1	400.00<	400.004	400.000	400.000	400.00(
MS0-10-0	TOT	ROUND-1	500.004	500,00(	4010.00	2630.003	500.00<
MSO-10-1	TOT	ROUND-1	500.00(	500.004	760.00	1140.60	500.004
MSD-10-2	TOT	ROUND-1	400.00N	400.00N	400.00N	400.00N	409.00N
MSE-10-3	TOT	ROUND-1	400.00{	400.000	400.000	400.00(	400.00<
MS0-10-4	TOT	ROUND-1	2000.004	2000.00<	2000.004	2000.000	2000.000
MSB-11-1	161	REUND-1	400.004	400.004	400.004	400.000	400.00{
MSC-11-2	TOT	ROUND-1	400,000	400.000	400.004	400.004	400.000
MSD-11-3	TOT	ROUND-1	400.004	400.00<	400.000	400.000	400.000
MSD-11-4	TOT	ROUND-1	500.00<	500.000	500.000	500.000	500.000
MSO-11-5	TOT	ROUND-1	400.00<	400.000	400.004	406.000	400.000
MS0-11-6	TOT	ROUND-1	500.00<	500.000	500.00<	500.000	500.060
HSO-11-7	TOT	ROUND-1	400.000	<b>4</b> 00.000	400.00	400.004	400.00

MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	N-Nitroso dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Fhen anthrene ppb	Pyrene ppb	1,2,4-Tri chloro benzene ppb
MS0-11-8	101	RBUND-1	400.00(	400.004	400.00<	400.064	400.000
NSO-11-9	TOT	ROUNG-1	400.00<	400.000	400.000	400.004	400.000
MSO-12-1	TOT	ROUND-1	560.00(	500.00(	1180.00	5920.00	500.00(
MSD-12-2	TOT	ROUND-1	400.000	400.00{	400.004	400.00	400.00{
MSD-12-3	TOT	ROUND-1	500.00{	500.004	500.00(	500.00{	500.00{
MS0-12-4	TOT	RDUND-1	400.004	400.000	400.00(	400.00{	460.00<
MSD-12-5	TOT	ROUND-1	400.00{	400.00{	400.00{	400.000	400.00(
MSD-13-1	TOT	ROUND-1	400.000	400.00{	460.00	2680.00	400.004
MSO-13-2	TOT	ROUND-1	400.00<	400.00<	400.000	400.064	400.000
NSO-13-3	TOT	RGUND-1	400.004	400.004	400.004	400.004	400.000
MSD-13-4	TOT	ROUND-1	400.00<	409.000	400.000	400.000	400.000
MSD-13-5	TOT	ROUND-1	400.00<	400.00(	400.000	400.000	400.00{
MSD-13-6	TOT	RCUND-1	400.004	400.00(	400.000	400.000	409.00<
NSQ-13-7	TOT	ROUND-1	460.004	460.00€	400.000	400.00(	400.000
MSE-13-8	107	round-1	400.00(	400.00{	400.000	400.000	400.000
MS0-14-1	101	ROUND-1	500.004	500.00(	610.00	500.00	560.064
MS0-14-2	TOT	ROUND-1	400.00(	400.000	400.000	400.00{	400.000
MS0-14-3	101	RSUND-1	500.00N	500.004	500.004	500.60(	500.004
MSD-14-4	TOT	RBUND-1	400.00<	400.000	400.000	400.000	400.000
NS0-14-5	TOT	RGUND-1	500.00(	500.00(	500.000	500.00(	500.000
KS0-15-2	101	ROUND-1	400.000	400.004	400.06:	400,000	\$00.000
MSG-15-3	TOT	KOUMD-1	400.00{	400.000	400.064	400.000	400.000
MS0-15-4	<b>TOT</b>	ROUND-1	400.000	400.000	400.000	400.00(	400.004
MSC-15-5	TOT	ROUND-1	400.00(	406.004	400.690	400.000	400.000
MS0-16-1	101	ROUND-1	500.000	500.00(	500.000	500.00(	500.00
MSD-16-2	TGT	ROUND-1	400.00(	460.004	400.004	400.000	400.000
MSD-16-3	101	ROUND-1	466.000	400.000	400.000	400.000	400.000
NSO-16-4	TOT	ROUND-1	400.000	400.004	400.00(	400.000	460.000
XS0-17-1	TOT	ROUND-1	800.000	2000.000	4500.00	6500.00	600,000
MSD-17-2	TOT	ROUND-1	500.000	500.964	500.664	500.000	500.000
MSD-17-3	101	ROUND-1	400.00(	400.064	400.004	400.00(	400.000
MSG-17-4	TOT	ROUND-1	506.000	500.000	500.00(	500.004	500.000

MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

	N-Ni troso	N-Nitroso			1,2,4-7ri
	dipropyl	diphenyl	Phen		chloro
	anine	amine(1)	anthrene	Pyrene	benzene
Sta Id Anl Event	bbp	ррь	ppb	ppt	ppb
MSO-18-1 TOT ROUND-1	800.004	800.00(	2050,00	4030.00	B00.00(
MSD-18-2 TOT ROUND-1	500.00(	500.00(	500.000	500.004	500.004
MSD-19-3 TOT ROUND-1	400.004	400.000	400.000	400.00(	400.004
MSO-19-1 TOT ROUND-1	100.00	400.000	600.000	1630.00	600.000
MSO-19-2 TOT ROUND-1	500.004	500.004	500.000	500.004	500.00{
MSC-20-1 TOT ROUND-1	500.00(	500.004	500.004	500.00(	500.00{
MSO-20-2 TOT ROUND-1	500.00<	500.004	500.000	500.004	500.00(
MSO-21-1 TOT ROUND-1	500.00(	500.00(	1130.60	1590.00	500.00<
MSO-21-2 TOT ROUNG-1	400.00<	800.00¢	£00.00(	400.000	800.00
MSO-21-3 TOT ROUND-1	800.00	400.000	400.000	800.00	400.004
MSO-22-1 TOT ROUND-1	500.00{	500.000	500.004	570.00	500.00{
MSD-22-2 TOT ROUND-1	1000.004	1000.000	1000.000	1200.00	1000.000
MSC-22-3 TOT ROUND-1	500.00{	500.000	500.000	500.000	500.00(
MSCA-OMS TOT ROUND-1	1320.00	330.004	330.000	1930.00	1420.00
MSD7-6MS TOT ROUND-1	960.00	330.00(	330.000	1790.00	1470.00
MSO7-7MS TOT ROUND-1	1330.00	330.000	330.060	1460.00	1230.00
REP-1 TOT ROUND-1	400.00{	400.004	400.000	400.00(	400.004
REP-2 TOT ROUND-1	400.000	400.00<	400.004	400.000	400.00<
REP-3 TOT ROUND-1	500.004	500.004	500.000	500.00(	500.00<
REP-4 TOT ROUND-1	400.000	400.004	400.004	400.000	400.000

MARINE SEDIKENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta ld	Anl E		Benzoic Acid ppb	2-Chloro phanol ppb	2.4-0: chlord phenal ppb	2,4-Bi . methyl phenol ppb	2,4-Di nitro phenol ppb	2-Methyl phenal ppb	4-Methyl phenol ppb	2-Nitro phenol ppb	4-Nitro phenol ppb	4-Chloro- 3-methyl phenol pab
T1-1	TOT RI	OUND-2	2000.004	400.004	400.000	400.004	2000.000	460.000	400.000	400.000	2000.000	400.00{
T10-1	TOT RE	OUND-2	2000.000	500.004	300.00<	500.004	2000.00<	500.00(	500.000	500.00(	2000.004	500.000
110-2	IDI SI	DUND-2	2000.000	400.00(	400.000	400.000	2000.000	400.00(	400.000	400.00	2000.30<	400.00{
T10-2-MS	TOT R	0UND-2	1700.004	3170.00	330.004	330.00<	1700.000	330.000	330.00<	330.000	3600.00	3400.00
T10-2M5D	TOT RI	0UND-2	1700.00(	4650.00	330.064	330.004	17 <b>0</b> 0.00<	330.060	330.000	330.000	3370.00	4690.00
T11-7	TOT RE	DUND-2	2000.00<	400.00<	400.000	400.00(	2000.00	400.00K	400.00<	400.000	2000.000	400.064
T12-1	TOT RE	0UND-2	2000.000	400.00<	400.000	400.00<	2000.000	400.000	400.004	400.00(	20 <b>00.00</b> 0	400.000
T16-1	TOT RE	OUND-2	2000.000	400.004	400.000	400.000	2000.000	400.00<	400.000	400.00(	2000.000	400.00(
T16-4	TOT RE	อบพธ-2	2000.000	400.000	400.004	400.004	2000.00<	400.000	460.60(	400.004	2000.000	400.000
716-4-KS	TOT RI	DUND-2	1700.000	5330.00	330.004	330.004	1700.004	330.000	330.000	330.0 <b>0</b> <	5790.00	5470.00
T16-4MSD	TOT RE	ยนพฎ-2	· 1700.004	3470.00	330.000	330.00(	1700.000	330.000	320.004	330.004	1700.00{	5320.00
T18-2	TOT R	0UK <b>0-</b> 2	2000.000	500.00K	500.00(	500.000	2000.00<	<b>50</b> 0.000	500.004	500.00(	2000.000	500.00(
12-1	TOT RE	OUND-2	2000.000	400.000	400.000	400.000	2000.000	409.000	400.004	400.00<	2000.000	460.000
12-5	TOT R	2-מאנים	2000.000	400.000	400.000	400.000	2000.000	400.000	400.00(	400.000	2000.000	400.00<
12-6	TOT R	DUND-2	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N
T22-1	TOT RE	CUND-2	5000.00N	1000.00N	1000.00N	1000.00N	5000.00N	1000.60N	1000.00N	1000.00N	5000.00N	1000.00N
122-2	TOT RE	OUND-2	4000.00N	700.00N	760.03N	700.00N	4000.00N	700.GCN	760.00N	700.00N	4000.00N	705.00N
T2A-5	TOT RE	OUND-2	2000.00N	400.00N	400.00H	490.00N	2000.00N	400.00N	400.00W	460.00N	2000.00N	400.00N
T2A-50	TOT RI	DUND-2	2000.00N	400.00N	400.00N	460.00N	2000.00N	400.00M	400.00N	400.00N	2000.00N	400.00N
13-2	TOT RI	DUKD-2	2000.004	400.00<	400.000	400.004	2000.000	400.000	400.000	400.00(	2000.004	400.000
T3-4	TOT R	OUND-2	2200.00<	400.00{	400.00<	400.004	2200.000	400.000	400.004	400.000	2200.000	400.00K
T3-5	TOT RI	DUND-2	2000.000	400.00(	400.000	400.000	2000.000	400.000	400.000	400.00(	2000.004	400.000
73-6	TOT RI	BUND-2	2000.004	400.004	400.000	400.000	2000.000	400.000	469.060	<b>40</b> 0.00<	2600.000	400.000
T3-6-MS	TOT R	GUND-2	1700.000	2700.00	330.004	330.004	1700.000	330.064	330.000	330.000	2830.00	2500.00
13-6-HSD	TOT R	ดบพท-2	3300.004	2600.00	<b>670.00</b> 0	670.00<	1700.00(	870.300	<b>576.00</b> (	570.00(	2900.00	2370.00
74-2	107 R	0UND-2	2000.00(	400.004	400.000	400.000	2000.69(	<b>40</b> 6,960	466.600	400.00(	2000.000	400.004
ï4-20	TOT R	0UND-2	2000.000	400.000	400.000	406.004	2000.004	400.000	400.0G	<b>4</b> 00.000	2000.000	400.000
T4-4	TOT RE	0UND-2	2000.00N	500.00N	500.00A	500.00N	2000.00N	500.00N	500.00N	500.00N	2000.00N	500.00N
75-0	TOT R	0UND-2	2000.004	400.00	400.004	400.064	2000.000	400.400	400. <b>0</b> 04	400.000	2000.600	400.000
16-1	TOT RI	DUAD-2	2000.004	400.000	460.000	400.000	2000.000	400.000	400,004	400.000	2000.000	400.004
T6-3	TOT 5	0UND-2	2000.000	400.000	400.000	460.004	2000.000	406.60	400.000	400.000	2000.000	400.000
TB-4	107 K	00NB-2	2000.004	400.000	400.000	400.000	2000.000	<b>40</b> 0.000	400.000	400.000	2000.000	400.000
TG-2	707 60	მა#0-2	2000.000	400.000	400.000	400.000	2000.00.	400.004	400.000	400.064	2000.000	400.00(
10-3	101 R	CUND-2	2000.004	400.000	406.060	400.000	2000.090	\$00.500	405.660	400.630	2000.00(	400.000

MARINE SEDIMENT SAMPLES - ASARCD SEMI-VOLATILES (ACIDS)

Sta Id	An l	Event	Penta chloro phanol ppb ,	Phenol ppb	2,4,5-Tri chloro phenol ppb	2,4,6-Tri chloro phenol ppb	Biphenyls ppb	Dibenzo thiophene ppb	Dimethyl analine ppb	Mathyl pheman thranes ppb	1 methyl (2-methyl ethylbenz ppb
							<del>-</del>				
T1-1	TOT	ROUND-2	2000.004	400.004	2000.004	400.000	400.0CN	400.00N	400.00N	400.00N	400.00N
710-1	TOT	ROUND-2	2000.004	500.00(	2000.00{	500.060	500.00N	500.00N	500.00N	500.00N	500.00N
110-2	101	RBUND-2	2000.00{	400.000	2000.004	400.00<	400.00N	400.00N	400.00N	400.00N	400.00N
T10-2-HS	TOT	ROUND-2	4300.00	3500.00	1700.000	330.000	330.00N	330.00N	330.00N	330.00N	330.00N
T10-2MSD	TOT	ROUND-2	3680.00	4660.00	1700.004	330.00<	330.00N	330.00N	330.00N	330.00N	330.00N
T11-7	TOT	ROUND-2	2000.00(	400.00{	2000.004	400.004	400.00N	400.00N	400.00N	400.00%	400.00N
T12-1	TOT	ROUND-2	2000.000	400.00(	2000.000	400.000	400.00N	400.06N	400.00N	400.00N	400.00N
T16-1	TOT	ROUND-2	2000.004	400.004	2000.00(	400.00<	400.00N	400.GON	400.00N	400.00N	400.00N
T16-4	TOT	ROUND-2	2000.004	400.000	2000.000	400.00<	400.00N	400.0GN	400.00N	400.00N	400.00N
T16-4-MS	TOT	ROUND-2	00.0084	5140.00	1700.000	330.00<	330.00N	330.00N	330.00N	330.00M	330.00N
T16-4MSD	TOT	ROUND-2	931.00	4760.00	1700.000	330.000	330.00N	330.00N	330.00N	330.00N	330.00N
T18-2	TOT	RGUND-2	2000.000	500.000	2000.064	500.00(	500.00N	500.00N	500.00N	500.00N	500.00N
12-1	TOT	ROUND-2	2000.00<	400.000	2000.000	400.004	400.00N	400.06N	400.CON	400.00N	400.00N
12-5	TOT	RCUND-2	2000.000	400.000	2000.000	400.000	400.00<	400.004	400.00<	400.00(	400.004
12-6	TOT	ROUND-2	2000.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T22-1	TOT	ROUND-2	5000.00N	1000.00N	5000.00N	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N
T22-2	TOT	ROUND-2	4000.00N	700.00N	4000.00N	700.00N	700,00N	700.00N	700.00N	700.00N	700.06N
T2A-5	TOT	ROUND-2	2000.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	400.00N	400.GON	400.00N
T2A-50	TOT	ROUND-2	2000.00N	400.00N	2000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2		ROUND-2	2000.00{	400.004	2000.000	400.004	400.00N	400.00N	400.00N	400.00N	400.00%
T3-4	TOT	ROUND-2	2200.004	400.000	2200.000	400.00(	400.004	400.050	400.000	400.000	400.000
13-5	101	ROUND-2	2000.000	400.004	2000.00<	400.000	400.000	40.00<	400.000	400.000	400.000
13-6	TOT	ROUND-2	2000.00(	400.00(	2000.000	400.000	490.00N	400.000	400.00K	400.00N	400.0GN
73-6-MS		RDUAD-2	3000.00	2070.00	1700.00(	330.000	330.00N	330.00N	330.00N	330.00N	330.00N
13-6-NSD	101	RCUND-2	2900.00	2600.60	3300.000	670.000	670.00N	670.00N	670.00N	670.60W	670.00N
14-2		ROUND-2	2000.000	400.000	2000.000	400.000	400.00N	400.60N	400.00%	400.00N	4001008
14-20	101	ROUND-2	2000.000	400.000	2000.000	400.000	400.00N	400.00N	4 <b>0</b> 0.00N	400.00N	400.00N
T4-4		ROUND-2	2000.00N	500.00N	2000.00N	500.00N	500.00N	500.)0N	500.00N	560.00N	500.00B
T5-0		RDUND-2	20 <b>0</b> 0.000	400.00(	2000.000	400,000	400.00N	400.00N	400.00N	400.00N	400.00N
76-1		RDUND-2	2000.000	400.000	2000.00(	400.000	400.0CM	400.00%	400.000	400.00N	400.00N
16-3		ROUND-2	2000.000	400.000	2000.000	400.00<	400.00N	400.06N	400.000	400.00N	400.00%
TE-4		ROUND-2	2000.000	400.004	2000.004	400.000	400.0GW	400.00N	400.00N	400.60N	400.00N
TO-2		ROUND-2	2000.000	400.600	2000.004	400.000	400.0CN	400.00N	400.06%	400.00N	400.00N
TO-3		ROUND-2	2000.004	400.004	2000.004	460.00(	490.00N	400.00N	400.00W	400.000	400.00N

Sta Id	Anl	Event	Ace naphthene ppb	Acenaph thylene ppb	Aniline ppb	Anthracne ppb	Benzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Banzo(b) fluor anthene ppb	Benzo (g,h,i) perylene ppb	Benzo(k) fluor anthene ppb	Benzyl Alcohol ppb	bis(2-chl orcethoxy )methane ppb
T1-1	TOT	ROUND-2	400.004	400.004	400.004	400.06{	3000.000	400.000	400.000	460.004	400.000	400.000	400.000	406.004
710-1	TOT	RDUND-2	500.00<	500.004	500.00<	500.00{	4000.604	1080.00	700.00	10BG.00	500.00(	500.000	500.00(	560.600
110-1	TOT	ROUND-2	500.00(	500.000	500.00(	500.004	4000.00	1080.00	760.06	1080.00	500.00<	<b>50</b> 0.00<	500.000	500.000
T10-2	TOT	ROUND-2	400.000	400.004	400.000	400.004	3000.000	400.000	400.000	400.000	400.004	400.00{	400.000	400.0 <b>0</b> <
T10-2-NS	TOT	RCUND-2	2480.00	330.0 <b>0</b> K	330.004	330.00<	2700.000	<b>3</b> 30.00(	330.000	330.000	330.00<	330.00{	330.00(	330.000
T10-2MSD	TOT	RGUND-2	2070.00	330.00(	330.000	330.004	2700.00<	<b>3</b> 30.000	330.004	330.000	330.00<	330.66(	330.00(	330.00<
T11-7	TOT	ROUND-2	400.000	400.004	400.000	400.004	3000.000	400.000	400.00(	400.000	400.000	400.00(	400.000	400.00<
T12-1	TOT	RCUND-2	510.00	400.004	400.004	400.000	3000.000	4100.00	1180.00	2540.00	400.06(	400.004	400.004	400.000
716-1	101	REUND-2	400.000	400.00(	400.000	400.00	3000.00<	400.000	400.060	400.000	400.000	400.004	400.000	406.00(
T16-4	TOT	ROUND-2	400.00{	400.000	400.000	400.00	3060.000	400.000	400.000	400.004	400.064	400.000	400.000	400.00(
716-4-HS	TOT	ROUND-2	2600.00	330.00<	330.000	330.00<	2700.000	330.00(	330.00(	330.00(	330.00<	330.00(	330.000	330.00<
T16-4MSD	TOT	FOUND-2	2720.00	330.06<	330.00<	330.00(	2700.000	330.000	330.000	336.000	330.00<	330.00(	330.004	330.00<
T18-2	TOT	ROUND-2	500.00(	500.004	500.000	500.004	4060.600	500.00(	500.00(	500.000	500.00(	<b>50</b> 0.00(	500.004	500.00(
72-1	TOT	ROUND-2	400.00<	400.004	400.004	400.00<	3000.000	400.004	400.000	400.00(	400.004	400.004	400.004	400.000
12-5	TOT	ROUND-2	400.00(	400.000	400.000	400.00	3000.00(	400.000	400.000	400.00(	400.004	400.000	400.000	400.00(
72-E	TOT	ROUND-2	400.00N	400.00N	400.000	400.0GN	3000.000	400.00N	400.00N	400.00N	400.00N	400.00%	400.00N	400.00N
122-1	701	ROUND-2	1000.00N	1000.00N	-3-	1000.00N	ŧ	1000.0CM	1000.GCN	1000.00N	1000.00N	1000.00M	1000.00M	1000.36N
122-2	707	ROUND-2	700.00N	700.00N	í	700.00N	ŧ	700.30N	700.00N	700.00N	700.00N	700.00N	700.00N	700.00N
72A-5	TOT	ROUND-2	400.00N	400.00N	400.000	400.00N	3000.000	400.06N	400.0GN	400.00N	400.00N	400.GON	400.00%	400.00N
T2A-50	TOT	ROUND-2	400.00N	400.00N	400.000	400.00N	3000.000	400.00%	400.0GN	400.00N	400.00N	409.00N	400.00N	400.00M
13-2	TOT	REUND-2	400.00(	400.060	400.064	400.000	3000.004	400.00%	400.000	400.000	460.000	400.000	400.00(	400.000
13-4	TOT	ROUND-2	400.000	400.000	400.000	460.000	3600,000	400.00(	400.000	400.000	400.000	400.000	400.000	400.000
13-5	107	ROUND-2	400.000	400.000	400.004	400.000	3000.000	400.000	400.064	400.00<	400.000	400.004	400.004	400.000
13-E	TOT	RDUND-2	400.000	400.000	400.000	400.004	3000.000	400.00(	400.064	460.006	400.00<	400.000	400.000	460.004
13-6-NE	TOT	ROUND-2	1230.00	330.00(	330.96(	330.000	2700.000	330.000	330.00(	330.664	330.000	<b>33</b> 6.664	330.00(	330.000
73-6-MSD	TOT	ROUNE-2	1209.60	470.00(	ŧ	340.00<	4	346,304	340.000	340.000	340.004	340.000	<b>670.0</b> 64	570.00K
14-2	TOT	ROUND-2	400.000	400.000	400.00	400.000	3000.00	400.000	400.00:	400.000	400.00(	400.00	400.000	400.000
74-20	TGT	ROUNG-2	400.004	400.000	400.000	400.000	3000,000	400.000	40).064	400.000	400.000	400.000	400.664	400.060
14-4	701	ROURD-2	500.00N	500.00N	500.004	500.00N	4000.000	500.00M	500.00M	500.00N	500.00N	<b>50</b> 0.06.1	590.00N	500.00M
15-0	TOT	ROUND-2	490.000	400.004	400.000	466.06<	<b>3000.</b> 004	1050.00	B&).00	2920.0 <b>0</b>	460.664	400.000	400.000	400.00(
7£-1	101	ROUNT-2	400.030	400.000	400.000	400.00(	3000.000	460.000	400.000	409.000	460.00<	400.000	460.090	460.000
76-3		ROUND-2	400.000	400.00(	400.00(	400.000	3000.000	400.000	400.000	400.000	400.000	400,000	400.00(	400.000
TB-4		ROUND -2	400.004	400.000	400.000	400.00(	3000.000	400.00	400,000	400.066	400.600	406.064	456.504	400.00(
70-2	TOT	RบับND−2	400.004	400.600	400,000	400.000	3000.000	406.00	400.00	400.000	400.00V	400.064	400.000	400.00(
TN-J	TIT	BBDND-5	400 003	460 800	460,000	455.GV	300 <b>.</b> 000	460,666	4en.65(	460,000	490.004	400.000	400.004	400.000

### MARIME SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	An1	Event	bis(2-chl oroethyl) ether ppb	bis(2-ch) oroisapro pyl)ether ppb	bis(2-eth ylhexyl) phthalate ppb	4-Brosech enyl-phen yl ether ppb	Rutyl benzyl phthalate ppb	4-Chloro aniline pph	2-Chloro naphthlne ppb	4-Chlorop henyl phe nyl ether ppb	Chrysène ppb	Dibenzo (a,h) anthracne ppt	Dibenzo furan ppb	1,2- Dictoro Senzene ppb
T1-1	TOT	ROUND-2	400.004	400.00(	400.004	400.000	400.004	400.000	400.00{	400.00<	400.004	400.004	400.004	400.004
T10-1	TOT	ROUND-2	500.004	500.000	3310.00	500.004	500.000	500.004	500.000	500.004	1910.00	500.00(	500.000	500.000
T10-1		ROUND-2	500.004	500.000	3310.00	500.000	500.004	500.000	500.004	500.000	1910.00	500.000	500.000	300.004
T10-2	TOT	ROUND-2	400.000	400.004	400.000	400.000	400.004	400.00(	400.000	400.00<	400.00{	400.00{	400.00<	400.004
T10-2-MS	tot	ROUND-2	330.004	330.004	330.004	339.000	330.00(	330.004	330.004	330.00(	330.00<	330.00(	330.000	330.000
T10-2MSB	TOT	ROUND-2	330.00(	330.00{	330.000	330.00<	330,004	330.000	330.00<	330.00<	330.00{	330.000	330.064	330.000
T11-7	TOT	ROUND-2	400.00{	400.004	400.004	400.004	400.004	400.000	400.000	400.004	400.000	400.004	400.000	400.004
T12-1	TOT	ROUND-2	400.00<	460.664	400.000	400.004	400.000	400.000	400.000	400.000	7190.00	400.004	1900.00	400.000
T16-1	TOT	ROUND-2	400.004	400.004	400.004	406.004	400.000	400.00K	400.000	400.000	400.00	400.09(	400.000	400.000
115-4	TOT	ROUND-2	400.004	400.004	400.00(	400.000	400.00<	400.00(	400.004	400.00<	400.00(	400.000	400.004	400.004
T16-4-MS	101	ROUND-2	330.000	330.00<	330.064	330.00	330.00<	330.004	330.000	330.000	330.000	330.00(	330.004	330.000
T16-4HS9	101	ROUND-2	330.00<	330.00<	330.000	330.004	330.000	330.00(	330.06(	330.000	330.004	330.00(	330.000	330.000
T18-2	TOT	ROUND-2	500.00<	500.004	<b>5</b> 00.000	560.004	500,004	500.000	500.00(	500.000	500.00<	500.000	500.00<	500.004
T2-1	TOT	ROUND-2	400.00<	400.000	400.004	400.000	400.004	400.000	400.004	460.000	400.000	400.00{	400.004	400.004
12-5	TOT	ROUND-2	400.004	400.004	400.004	400.004	400.000	409.000	400.00{	400.000	400.000	400.0ó<	400.000	400.000
12-6	TOT	ROUND-2	400.00N	400.00N	400.00N	400.00M	460.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T22-1	101	ROUND-2	1000.00N	1000.00N	1000.06N	1000.00N	1000.00N	1000.00N	1000.0CM	1000.00N	1000.00N	1000.00N	1000.00W	1000.00N
122-2	TOT	ROUND-2	700.00N	700.00N	700.00N	700.00N	700.00N	700.60N	700.0CN	760.00N	700.00N	700.00M	700.00N	700.00N
T2A-5	TOT	ROUND-2	400.GON	400.00N	400.00N	400.00N	400.00N	400.00W	400.00N	400.00N	400.00N	400.00N	400.000	400.00N
T2A-50	<b>TOT</b>	ROUND-2	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CN	400.00N	400.00%	400.06N	400.00N
13-2	101	ROUND-2	400.000	400.064	400.000	400.900	400.000	400.000	400.060	400.00<	400.000	400.004	400.000	400.00{
13-4	TOT	KOUND-2	400.00<	400.004	400.564	400.004	400.000	400.000	400.000	400.000	400.004	400.00(	400.000	400.004
<b>13-</b> 5	TOT	ROUND-2	400.000	400.604	400.000	460.000	400.000	400.000	400.004	400.00<	400.004	400.004	400.00(	400.004
13-6	TOT	ROUND-2	400.000	400.00	400.000	400.00(	400.000	400.000	400.00(	400.000	400.000	400.000	400.000	400.000
T3-6-H3	TOT	ROUND-2	330.000	330.000	330.000	330.000	330.000	330.004	330.000	330.000	330.00(	330.000	330.004	330.000
13-4-KSD	101	REUND-2	570.06€	670.000	340.000	340.064	340.000	<b>570.00</b> 0	<b>570.0</b> 00	340.000	340.000	340,000	240.60€	670.000
14-2	101	ROUND-2	400.00(	400.000	400.000	400.000	400.00(	400.000	400.000	400.000	400.000	400.000	400.000	400.004
74-20	TOT	ROUND-2	400.00<	400.000	400,00%	400.000	400.000	400.0%	400.000	400.00<	460.000	400.000	400.004	400.000
T4-4	101	ROUND-2	500.00N	500.00N	500.00N	500.00N	1080.00J	300.06N	500.00N	500.00N	500.00N	500.00N	500,00N	590.9 <b>0</b> %
T5-6	701	ROUND-2	400.00(	400.004	400.000	400.000	400.000	400.000	400.000	400.00<	1650.00	400.000	400.00(	460.000
16-1	101	RGUND-2	400.004	400.000	400.064	400.00(	400.000	460.000	469.000	400.000	460.660	400.000	460.004	400.000
16-3	181	RGUND-2	400.000	400.004	400.004	400.000	400.064	400.004	400.00	400.004	400.000	400.00	400.000	400.000
16-4		ROUND-2	460,000	400.000	400.004	400.000	400.000	409.000	400.000	400.000	400.00<	400.004	400.000	400.004
TO-2		ROUND-2	400.000	400.00(	400,600	460.00(	400.000	400.000	400.000	409.000	400.000	400.000	400.004	400.004
70-3		ROUND-2	400.004	400.000	400.060	400.000	400.000	400.004	460.000	400.000	400.000	400.064	400.004	400.004

MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl Event	1,3- Dichloro benzene ppb	1,4- Dichloro benzene ppb	3,3'- Dichloro benzidine ppb	Diethyl phthalate ppb	Dimethyl phthalate ppb	Bi-n- Butyi phthalate ppb	2,4- Dinitro toluene ppb	2,6- Dimitro taluene ppb	Di-n- Octyl Fhthalate ppb	Fluor antheme ppb	Fluorene ppb	Hexa chloro benzena ppb
T1-1	TOT RGUND-2	400.004	400.00	700.00{	400.000	400.000	400.000	400.6 <b>0</b> (	400.00(	400.00	400.004	400.00K	409.004
T10-1	TOT ROUND-2	500.00(	500.004	900.00(	500.004	500.000	500.000	500.004	500.00(	500.004	3510.00	500,004	500.000
T10-1	TOT FOUND-2	500.00{	500.004	900.000	500.00(	500.004	500.000	500.00<	500.00(	560.604	3510.00	500.004	500.00(
T10-2	TOT ROUND-2	400.004	400.000	800.00<	400.004	400.00<	400.00<	400.60K	400.000	400.000	400.000	400.000	400.000
	TOT ROUND-2	330.00<	2140.00	£70.00(	330.0 <b>0</b> <	330.00<	330.00(	2330.00	330.00(	330.000	330,000	330.00{	330.00(
T10-2MSD	TOT ROUND-2	330.00<	3190.00	£70.03<	330.00(	330.00(	330.000	1890.00	330.004	330.00(	330.004	330.004	330.000
711-7	TOT ROUND-2	400.004	400.004	900.000	400.00<	400.00	400.000	400.000	400.004	460.004	400.000	460.064	400.000
T12-1	TOT ROURD-2	400.00<	460.00K	900.000	400.6 <b>0</b> <	400.004	460.000	400.000	400.00(	400.00<	43600.00	400.000	400.000
T16-1	TOT KOUND-2	400.004	400.000	800.000	400.000	400.004	400.000	400.000	400.000	400.064	400.004	400,000	400.00(
716-4	TOT ROUND-2	400.000	400.000	800.000	400.00<	400.064	400.000	400.000	400.00(	400.00{	400.000	400.060	400.004
T16-4-MS	TOT ROUND-2	330.00<	2230.00	£60.06K	330.00(	330.00<	330.00K	2980.00	330.000	330.004	330.000	330.000	330.000
T16-4MSD	TOT ROUND-2	330.00<	2320.00	860.000	330.60<	330.00<	330.00<	2150.60	330.000	330.00(	330.004	330.00<	330.000
116-2	TOT ROUND-2	500.00(	500.00(	900.000	500.004	500.004	500.000	500.0 <b>0</b> <	500.00(	500.000	500.000	500.060	500.000
T2-1	TOT ROUND-2	400.000	400.000	700.00(	400.004	400.00<	400.004	400.00(	400.604	400.000	400.004	400.004	460.000
12-5	TOT ROUND-2	400.004	400.00(	800.000	400.000	400.004	400.000	400.000	400.000	400.000	400.600	406.000	400.00K
12-6	TOT ROUND-2	400.GGN	400.00N	B00.00N	400.00N	400.00N	400.00M	400.00N	400.00N	400.00N	400.00N	460.99N	400.00N
122-1	TOT ROUND-2	1000.00N	1000.00N	2000.00N	1600.00N	1000.00N	1000.00W	1000.00N	1000.00N	1000.00N	1000.00N	1000.06N	1000.00N
122-2	TOT ROUND-2	700.00N	700.00N	1000.00N	700.00N	700.00W	700.00M	760.00N	700.00N	700.00N	700.0CB	700.00N	700.00N
12A-5	TOT KOUND-2	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N	400.00M	469.00N	400.00N	400.00N	400.00H	400.00N
T2A-53	TOT ROUND-2	400.00N	400.0CM	300.00N	400.00N	400.00N	400.00%	400.00N	406.00%	400.00N	400.00N	400.00N	460.30N
13-2	TOT ROUND-2	460.000	400.004	860.060	400.000	400.00<	400.004	400.000	400.004	400.000	400.004	400.00(	400.00(
73-4	TOT ROUND-2	400.000	400.000	900.000	460.000	400.000	400.66%	400.000	460.000	400.004	400.000	400.00(	400.004
13-5	TOT ROUND-2	400.000	400.004	800.064	400.000	400.000	406.000	490.000	400.000	460.004	400.004	400.00(	400.000
T3-6	10T ROUND-2	400.000	400.064	900.000	400.00(	400.00<	400.604	400.000	400.000	450.000	4(0.00)	400.000	400.00(
T3-6-MS	TOT ROUND-2	330.000	1030.00	670.000	330.000	330.000	330,000	330.000	330.00(	330.000	330.000	330.000	330.000
13-6-MSD	TOT ROUND-2	<b>570.0</b> 00	830.00	450.0%	340.00<	<b>470.00</b> €	346.004	1300.00	346.000	, 340.000	340.000	340.660	340.000
14-2	TOT ROUND-2	400.000	400.000	B00.00(	400.000	400.00	400.604	<b>40</b> 0.064	400.000	400.000	400.00K	490.300	400.000
74-20	TOT ROUND-2	460.000	400.004	900.000	460.600	400.660	400.000	400.000	400.000	400.0 <b>0</b> 0	400.030	400.00	400.00<
T4-4	707 ROUND-2	500.00N	500.00N	1000.00N	500.00N	500.00N	5 <b>0</b> 0.00∜	500.00N	500.00N	1220.003	506.00N	500.06N	500.00N
T5-0	TOT ROUND-2	400.000	400.000	950.Q0K	400.000	<b>40</b> 0.000	400.50	400.00	400,000	400.00(	6210.00	400.004	400.00(
76-1	TOT ROUND-2	400.004	400.000	700.000	460.004	400.00	406.000	400.000	460.000	400.00<	400.000	400.004	430.004
16-3	TOT KOUND-2	400.000	460.00<	800.000	460.000	400.600	400.00%	400.000	400.000	400.000	400.00%	400.304	400.000
18-4	TOT ROUND-2	4 <b>0</b> 0.000	400.000	800.000	400.0 <b>0</b> <	400.000	469.660	400.080	400.000	400.000	400.000	460.000	400.064
10-2	TOT ROUND-2	400.004	400.000	700.36(	400.00(	400.000	460,000	400.00/	460.000	400.0 <b>0</b> 0	400.000	400.000	400.000
10-3	TOT ROUND-2	406.007	400.600	700.000	400.00(	400.00{	400.00K	400.004	\$60.000	400.00(	<b>40</b> 0.004	400,664	400.00(

#### MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl i	Event	Heva chloro butadiene ppb	Hexachlor ocyclopen tadiene ppb	Hexa chloro ethane ppb	Indeno (1,2,3-cd Pyrene ppb	Iso phorone ppb	2-Methyl naphthlne ppb	Naphthlne ppb	2-Nitro aniline ppb	3-Nitro aniline ppb	4-Mitro aniline ppb	Nitro benzene pph	N-Nitroso dinethyl amine ppb
11-1	191 1	ROUND-2	400.00(	400.000	400.00(	400.000	400.00<	400.000	400.00<	2600.004	2000.004	2000.00(	400.004	400.000
T10-1	TOT I	ROUND-2	500.004	500.004	500.004	500.000	500.004	500.00<	500.00<	2000.000	2000.004	2000.000	500.000	500.004
T10-1	TOT I	ROUND-2	500.00<	500.00<	500.004	500.000	500.00(	500.000	500.004	2000.000	2000.00<	2000.000	500.000	500.00<
T10-2	TOT I	ROUND-2	400.004	400.004	400.004	400.000	400.00<	400.004	400.000	2000.004	2000.000	2000.000	400.000	400.000
T10-2-MS	TOT	ROUND-2	330.00{	330.004	330.00(	330.00K	330.00(	<b>3</b> 30.00(	330.00<	1700.000	1700.004	1700.600	330.004	330.064
T10-2MSD	TOT	ROUND-2	330.000	330.00<	330.00(	330.000	330.000	330.000	330.00<	1700.000	1700.000	1700,000	330.004	330.000
T11-7	TOT I	ROUND-2	400.000	400.004	400.004	400.000	400.004	400.000	400.000	2000.004	2000.000	2000.004	400.000	400.004
112-1	TOT	ROUND-2	400.00<	400.004	400.004	470.00	400.004	460.00(	400.00K	2000.004	2000.00(	2000.000	400.064	400.000
T16-1	TOT S	ROUND-2	400.00<	400.004	400.00;	400.004	400.004	400.004	460.004	2000.004	2000.004	2000.000	400.00<	400.004
T16-4	TOT F	ROUND-2	400.000	400.000	400.004	400.004	400.000	400,004	460.604	2000.00(	2000.000	2000.00{	400.000	400.000
T16-4-MS	TOT F	ROUND-2	330.000	330.00(	330.004	330.00(	330.00<	330.000	330.00<	1700.00<	1700.004	1700.000	330,000	330.000
T16-4MSD	TOT !	ROUND-2	330.004	330.00<	330.000	330.004	330.000	330.000	330.000	1700.000	1700.004	1700.00(	330.000	330.000
T18-2	TOT F	ROUND-2	500.000	500.004	500.00€	500.004	500.000	500.000	500.00<	2000.00(	2000.000	2000.000	500.000	500.004
T2-1	TOT	ROUND-2	400.004	400.004	400.000	400.000	400.004	400.064	400.000	2000.000	2000.000	2600.000	409.004	400.00%
12-5	TOT	ROUND-2	400.000	400.004	400.000	400.004	400.004	400.00(	400.00<	2000.000	2000.000	2000.000	400.03<	400.004
12-6	101.1	ROUND-2	400.00N	400.00N	400.00N	400.00%	400.00N	400.00N	400.06N	2000.00N	2000.00N	2000.00N	400.00N	409.000
122-1	TOT	ROUND-2	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N	1000.00%	1000.00N	5000.00N	5000.00N	5000.00h	1000.66N	
122-2	TOT I	ROUND-2	700.00N	700.00N	700.00N	700.00N	700.00N	700.60N	760.00N	4000.00N	4000.00N	4000.00N	700.00N	
T2A-5	707 (	FOUND-2	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.09N	2000.00N	400.00N	400.00N
12A-50	TOT I	ROUND-2	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
13-2	101 1	ROUND-2	400.004	400.004	400.000	400.000	400.000	400.000	400.000	2000.000	2000.004	2000.000	400.054	460.00(
73-4	TOT	ROUND-2	400.004	400.000	460.060	400.004	400.000	400.004	400.00(	2200.000	2200.000	2200.000	400.004	400.00(
13-5	TOT I	ROUND-2	400.000	400.004	400.00(	400.004	400.000	400.000	400.000	2000.000	2000.000	2000.000	400.000	400.000
13-6	TOT 9	ROUND-2	400.00€	400.004	400.000	400.004	400.00<	400.000	400.000	2000.004	2000.004	2000.000	400.00(	460.004
13-6-MS		ROUND-2	330.00<	370.004	330.004	330,000	330.00(	330.000	330.004	1700.004	1700.000	1700.00(	330.00(	339.000
13-6-MSD			670.00(	<b>670.00</b> €	670.004	340.000	<b>670.</b> 000	<b>579.</b> 000	<b>670,00</b> €	3300.000	1700.004	1700.000	670.000	
19-2		ROUND-2	400.004	400.000	400.007	400.000	400.00(	400.000	400.000	2000.004	2000,000	2000.060	400.000	4(0.00(
14-20	TOT (	ROUND-2	400.004	400.000	400.004	400.0 <b>0</b> 0	490.00(	400.000	400.000	2060.060	2000.00(	2000.00(	400.000	400.000
T4-4		ROUND-2	500.00N	500.00N	500.00N	500.00%	500.00N	500.00พ	500.00H	2000.00N	2000.00N	2006.00%	500.00N	500.00N
15-0		ROUND-2	400.000	400.000	400.000	400.004	400.000	400.00(	400,000	2000.000	2000.004	2000.000	400.000	400.004
76-1		PÓUND-2	400.000	400.00<	400.000	400.000	400.000	400.000	400.000	2000.000	2000.000	2000.004	400.004	400.004
T6-3		ROUND-2	400.004	400.004	400.000	460.000	400.004	400.000	400.064	2000.060	2000.004	2000.000	460.000	400.00<
TE-4		ROUND-2	400.004	400.00(	400.004	400.000	460.300	400.00	400.000	2000.007	2000.000	2000.000	400.000	406.004
10-2		ROUND-2	400.004	400.000	400.00(	400.064	400.000	400.000	400.000	2000.000	2030.004	2000.004	400.000	400.000
10-3		ROUND-2	400.00(	400.00(	400.004	400.00<	400.000	400.000	400.000	2060.000	2000.000	2000.004	400.004	400.004

Se bo 1"

			N-Ni troso	N-Ni troso			1,2,4-Tri		Tctal
			di propy!	diphenyl	Phen		chloro		Organic
			amine	amine(1)	anthrene	Pyrene	benzene	PCSs	Carbon
Sta Id	Anl	Event	ppb	app	pap	ppb	ррь	ppb	ppa ppa
T1-1		ROUND-2	400.00<	400.00K	400.000	400.000	400.004	<b>20</b> 6.064	810.0
110-1		ROUND-2	500.004	500.00<	1870.00	3370.00	500.00(	3000.03K	4800.0
110-1	707	ROUND-2	500.004	500.0 <b>0</b> <	1870.00	3370.00	500.00(	3000.004	4800.0
T10-2	TOT	ROUND-2	400.00<	400.004	400.000	400.0 <b>0</b> <	400.00<	200.000	1600.0
110-2-HS	TGT	ROUNE-2	1490.00	330.004	330.0 <b>0</b> <	2570.00	2260.00	12500.00	3700.0
T10-285D	101	ROUND-2	2130.00	330.000	330.00<	2280.00	1720.00	12400.00	3100.0
T11-7	TOT	ROUND-2	400.00<	400.004	400.004	400.004	400.000	300.000	1100.0
J12-1	TET	ROUND-2	400.00<	400.00(	52900.00	27100.00	400.00<	3000.000	5300.0
T16-1	101	RGUND-2	400.00<	400.004	400.00(	400.00<	400.00<	300.000	2800.0
T16-4	101	ROUND-2	400.00<	400.004	400.004	400.0 <b>0</b> (	400.004	200.000	2200.0
T16-4-HS	101	RDUND-2	3040.00	330.00{	330.000	2990.00	2390.00	12700.60	4900.0
T16-4MSD	TOT	ROUND-2	2970.00	330.00{	330.004	3260.00	2590.00	12700.00	1566.0
118-2	TOT	RDUND-2	500.00(	500.004	500.00(	500.00{	500.00<	300.000	2800.0
T2-1	TOT	ROUND-2	400.00(	400.604	400.064	400.00(	400.000	200.000	#
12-5	TOT	ROUND-2	400.60<	400.000	400.004	400.004	400.000	200.00(	1300.0
T2-6	101	ROUND-2	400.0CN	400.00N	400.00N	400.00N	400.00N	200.00M	1500.0J
722-1	TOT	ROUND-2	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N	6000.00N	*
122-2	TOT	ROUND-2	760.60N	700.00N	700.00N	706.00N	700.00N	2000.00N	6800.0J
T2A-5	TOT	ROUND-2	400.00N	400.00N	400.00N	400.00N	400.00N	200.00W	2000.03
T2A-50		ROUND-2	400.00N	400.00N	400.60N	406.00N	400.00N	200.00N	1500.03
13-2		ROUMO-2	400.00(	400.00(	400.00(	400.000	400.000	200.000	1100.0
T3-4	TOT	ROUND-2	400.004	400.004	400.000	400.004	400.00(	300.000	1700.0
13-5		ROUND-2	400.00K	400.000	409.090	400.00(	400.000	200.000	2200.0
13-E	TOT	ROUND-2	400.004	400.001	400,500	400,004	400.000	300.000	1409.0
13-6-KS	TOT	ROUND-2	1030.00	330.004	330.000	1070.00	1070.00	12500.00	27:30.0
T3-L-MSD	TOT	R0958-2	900.00	340.09(	340.00<	1196.00	530.00	12200.00	5000.0
14-2	TOT	ROUND-2	400.000	400.000	400.000	400.000	400.000	260, 350	1700.9
14-20	161	RGUND-2	4 <b>0</b> 0.054	406.06(	400.000	469.09(	400.000	266.06	1100.0
T4-4	707	ROUND-D	500.00N	500.00N	500.00 <b>%</b>	500.00N	500.00N	300.00%	2766.60
<b>75-</b> 0	101	ROUND-2	400.000	400.060	400.000	1310.00	400,000	300.004	1400.0
16-1	101	ROUND-2	400.004	400.00(	400.000	400.600	400.000	200.000	1100.0
T6-3	ter	ROUND-2	400.004	400,000	400.007	4(0.600	400.000	200.000	1900.0
T8-4	707	RGUND-2	400.600	400.00(	490.000	400.000	400.004	200.00	4300.0
<b>10-</b> 2		ROUND-2	400.000	400.000	400.000	400.004	400.000	200.000	770.0
TO-T	ίυι	₽0UND-2	400.064	46a.66(	400.000	400.000	400.6 <b>6</b> K	200.000	

	_	Course	Medium	<u></u> .	
SAMFILE #	Gravel >2mm	Sand	Sand .525mm	Fines	Fercent
		1 mm	. J ZJMM :=======	<.25mm	Recovery
MSG 1-1	35.52	12.36	28.69	23.52	100.09
MSG 2-1	50.50	7.06	24.54	17.72	99.81
MSG 2-2	24.44	2.04	36.07	36.72	99.27
MSG 2-3	3.28	1.58	68.86	25.47	99.18
MSG 3-1	11.52	1.78	40.42	44.33	98.04
MSG 3-2	2.34	3.28	79.73	14.45	99.81
MSG 3-3	8.80	7.52	67.33	15.75	99.40
MSG 4-0	7.87	5.27	38 <b>.</b> 99	45.74	97.88
MSG 4-1	30.0 <del>9</del>	22.14	37.58	6.79	96.60
MSG 4-1	46.42	26.17	22.45	4.41	99.44
MSG 4-2	47.02	21.90	19.14	8.41	96.48
MSG 4-3	22.91	26.00	30.70	19.96	99.57
MSG 5-0	3.64	_ 4.55	47. 33	43.52	99.04
MSG 5-1	41.65	30.14	25.18	3.27	100.24
MSG 5-2	12.73	25.55	53.21	7.89	99.38
MSG 5-3	3.14	3.26	78.84	14.76	100.00
MSG 6-0	6.43	3.64	38.63	49.83	98.52
MSG 6-1	31.75	25.76	35.27	7.26	100.03
MSG 6-2 MSG 6-3	25.51 3.72	25.79	36.6Ø	10.94	98.84
MSG 6-4	0.60	5.95 0.30	66.46 77.62	23.13 20.51	99.26
MSG 7-1	96.36	1.86	0.47	1.38	99.02 100.06
MSG 7-2	24.59	26.86	38.75	9.14	99.34
MSG 7-3	45.65	23.31	18.86	11.67	99.49
MSG 7-4	2.56	1.17	66.27	29.25	99.24
MSG 7-5	3.50	1.15	65.58	28.83	99.06
MSG 7-6	10.16	0.60	66.07	22.37	99.19
MSG 7-7	0.82	0.43	86.04	12.87	100.17
MSG 8-1	2.15	6.65	58.37	30.90	98.07
MSG 8-2	2.70	2.43	62.88	31.20	99.22
MSG 8-3	12.24	3.52	44.75	38.91	99.42
MSG 8-4	12.52	2.90	40.97	40.49	96.88
MSG 9-1	Ø.39	0.81	21.84	75.70	98.74
MSG 9-2	4.05	2.97	64.73	27.16	98.92
MSG 9-3	1.83	3.03	71.38	23.50	99.74
MSG 9-4	2.10	2.41	67.42	26.18	98.12
MSG 9-5	2.92	1.12	68.39	26.89	99.31
MSG 9-6	1.41	0.30	75.79	20.82	<b>98.</b> 32 -
MSG 9-7	0.05	0.34	86. 90	11.61	98.90
MSG 9-8	0.00	0.09	88.34	10.73	99.16
MSG 10-0	9.19	2.86	39.28	46.81	98.14
MSG 10-1	18.94	10.34	47.57	22.56	99.40
MSG 10-2	5.36	2.57	68.44	22.61	98.98
MSG 10-3	1.25	2.32	69.75	26.26	99.57
MSG 10-4	2.58	2.87	71.12	22.85	99.43
MSG 11-1	7.83	9.66	60.50 25.50	20.94	98.93
MSG 11-2 MSG 11-3	46.05 8.74	8.04	25.50 67.07	19.09 17.33	98.68 98.99
MSG 11-3	11.71	5.85 2.71	46.92	36.96	98.29
MSG 11-4	7.03	3.24	59.40	28.71	98.39
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		Course	Medium		
SAMPLE	Gravel	Sand	Sand	Fines	Percent
#	> 2mm	1 mm	.525mm	(.25mm	Recovery
222222222	**********	=========	.=========	=======	=========
MSG 11-6	14.82	2.80	51.01	32.33	100.95
MSG 11-7	0.10	0.29	72.05	26.96	99.40
MSG 11-8	0.00	0.12	84.30	15.25	99.67
MSG 11-9	Ø. Ø7	Ø. 14	83.53	14.74	98.47
MSG 12-1	42.95	7.59	14.79	35.11	100.45
MSG 12-2	18.26	8.73	53.07	19.15	99.21
MSG 12-3	20.50	5. 92	32.24	41.08	99.73
MSG 12-4	3.19	1.82	55.34	39.20	99.55
MSG 12-5	2.63	2.39	67. 09	27.87	99.98
MSG 13-1	43.45	9.38	33.34	12.99	99.17
MSG 13-2	0.72	0.52	68.88	28.29	98.40
MSG 13-3	17.08	4.55	41.43	35.56	98.62
MSG 13-4	1.96	1.21	50.59	45. Ø2	98.77
MSG 13-5	17.00	7.44	56.10	19.49	100.02
MSG 13-6	ଫ. ହହ	Ø. 24	61.22	37.62	99.08
MSG 13-7	Ø.32	0.11	64.66	34.20	99.29
MSG 13-8	0.00	0.10	71.95	27.27	99.32
MSG 14-1	42.82	8.00	16.31	31.64	98.76
MSG 14-2	Ø. 92	1.94	64.40	31.47	98.73
MSG 14-3	16.54	4.42	41.77	36.27	99.00
MSG 14-4	5.20	2.28	40.42	50.98	98.89
MSG 14-5	0.04	Ø.24	<b>55.</b> 33	43.25	98.86
MSG 15-2	12.74	1.72	31.10	53.48	99.04
MSG 15-3	4.28	1.68	46.15	46.59	98.69
MSG 15-4	4, 63	3.71	44 <b>.</b> 97	46.10	99.40
MSG 15-5	0.40	0.70	40.66	57.45	99.22
MSG 16-1	0.50	0.55	32.57	65.14	98.76
MSG 16-2	0.43	0.55	34.29	63.39	98.66
MSG 16-3	<b>0.</b> 57	0.30	48.53	49.59	98.99
MSG 16-4	Ø. ØØ	0.12	43.69	54.70	98.51
MSG 17-1	7.64	4.67	18.18	64.33	94.83
MSG 17-2	Ø.39	0.50	36.60	61.39	98.88
MSG 17-3	16.80	3.67	26.16	52.89	99.52
MSG 17-4	0.09	Ø.37	37.67	60.42	98.55
MSG 18-1	12.96	5.53	10.45	66.60	95.54
MSG 18-2	0.74	Ø.57	34.12	63.10	98.53
MSG 18-3	1.95	1.32	50.69	45.06	99.03
MSG 19-1	1.36	0.61	26.39	69.78	98.14
MSG 19-2	1.48	0.78	46.95	49.12	98.32
MSG 20-1	5.82	1.11	49.76	41.89	98.58
MSG 20-2	1.86	Ø.86	62.95	33.10	98.76

Station		Coarse	Medium		
Number	Gravel	Sand	Sand	Fines	Percent
	) 2mm	1 rara	.525mm	(.25mm	Recovery
	=============			========	
T1-1	35.52	12.36	28.69	23.52	100.09
T2-1	50.50	7.06	24.54	17.72	99.81
T2-2	24.44	2.04	36.07	36.72	99.27
T2-3	3.28	1.58	68.86	25.47	99.18
T2A-5	12.90	3.20	60.40	23.40	99. 90
T2-5	7.40	0.50	69.70	22.30	99. 90
T2-6	4.30	1.00	76.30	18.50	100.10
T3-1	11.52	1.78	40.42	44.33	98.04
T3-2	2.34	3.28	79.73	14.45	99.81
T3-3	8.80	7.52	67.33	15. <i>7</i> 5	99.40
T3-4	6.40	9.70	61.50	22.40	100.00
T3-5	2.30	3.70	66.00	28.00	100.00
T3-6	4.80	5.30	70.80	19.10	100.00
T4-0	7.87	5.27	38.99	45.74	97.88
T4-1	46.42	26.17	22.45	4.41	99.44
T4-2	47.02	21.90	19.14	8.41	96.48
T4-3	22.91	26.00	30.70	19.96	99.57
T4-4	3.00	2.40	67.80	28.40	101.60
T4-4rep	1.30	2.40	67.80	28.40	99.90
T5-0	3.64	4.55	47.33	43.52	99.04
T5-1	41.65	30.14	25.18	3 <b>.</b> 27	100.24
T5-2	12.73	25. 55	53.21	7.89	99.38
T5-3	3.14	3.26	78.84	14.76	100.00
T6-0	6.43	3.64	38.63	49.83	98.52
T6-1	31.75	2 <b>5.</b> 76	35.27	7.26	100.03
T6-2	25.51	25.79	36.60	10.94	98.84
T6-3	3.72	5.95	66.46	23.13	99.26
T6-4	0.60	0.30	77.62	20.51	99.02
T7-1	96.36	1.86	Ø. 47	1.38	100.06
T7-2	24.59	26.86	38.75	9.14	99.34
T7-3	45.65	23.31	18.86	11.67	99.49
T7-4	2.56	1.17	66.27	29.25	99.24
T7-5	3.50	1.15	65.58	28.83	99.06
T7-6	10.16	0.60	66.07	22.37	99.19
T7-7	0.82	Ø. 43	86.04	12.87	100.17
T8-1	2.15	6.65	58.37	30.90	98.07
T8-2	2.70	2.43	62.88	31.20	99.22
T8-3	12.24	3,52	44.75	38.91	99.42
T8-4	12.52	2.90	40.97	40.49	96.88
T9-1	0.39	0.81	21.84	75.70	98.74
T9-2	4.05	2.97	64.73	27.16	98.92
T9-3	1.83	3.03	71.38	23.50	99.74
T9-4	2.10	2.41	67.42	26.18	98.12
T9-5	2.92	1.12	68.39	26.89	99.31
T9-6	1.41	0.30	75.79	20.82	98.32
T9-7	0.05	Ø. 34	86.90	11.61	98.90
T9-8	ବ. ଡଡ	0.09	88.34	10.73	99.16
T10-0	9.19	2.86	39.28	46.81	98.14
T10-1	18.94	10.34	47.57	22.56	99.40

Station		Coarse	Medium		
Number	Gravel	Sand	Sand	Fines	Percent
	> 2mm	1 rora	.525mm	(.25mm	Recovery
=					
T10-2	5.36	2.57	68.44	22.61	98. <del>9</del> 8
T10-3	1.25	2.32	69.75	26.26	99.57
T10-4	2.58	2.87	71.12	22.85	99.43
T11-1	7.83	9.66	60 <b>.</b> 50	20.94	98.93
T11-2	46.05	8.04	25.50	19.09	98.68
T11-3	8.74	5.85	67.07	17.33	78.99
T11-4	11.71	2.71	46.92	36 <b>.</b> 96	98.29
T11-5	7.03	3.24	59.40	28.71	<del>9</del> 8.39
T11-6	14.82	2.80	51.01	32.33	100.95
T11-7	0.10	0.29	72.05	26.96	99.40
T11-8	0.00	0.12	84.30	15.25	99.67
T11-9	Ø. Ø7	Ø. 14	83.53	14.74	98.47
T12-1	42.95	7.59	14.79	35.11	100.45
T12-2	18.26	8.73	53.07	19.15	<del>99</del> .21
T12-3	20.50	5.92	32.24	41.08	99.73
T12-4	3.19	1.82	55.34	39.20	99.55
T12-5	2.63	2.39	67. Ø9	27.87	99.98
T13-1	43.45	9.38	33.34	12.99	99.17
T13-2	Ø.72	Ø.52	68.88	28.29	98.40
T13-3	17.08	4 <b>.</b> 5 <b>5</b>	41.43	35.56	98.62
T13-4	1.96	1.21	50.59	45.02	98.77
T13-5	17.00	7.44	56.10	19.49	100.02
T13-6	0.00	0.24	61.22	37.62	99.08
T13-7	0.32	0.11	64.66	34.20	99.29
T13-8	0.00	0.10	71.95	27.27	99.32
T14-1	42.82	8.00	16.31	31.64	98.76
T14-2	Ø. 92	1.94	64.40	31.47	98.73
T14-3	16.54	4.42	41.77	36.27	99.00
T14-4	5.20	2.28	40.42	50.98	98.89
T14-5	0.04	Ø.24	55.33	43.25	98.86
T15-2	12.74	1.72	31.10	53.48	99.04
T15-3	4.28	1.68	46.15	46.59	98.69
T15-5	0.40	0.70	40.66	57.45	99.22
T16-1	0.50	Ø. 55	32.57	<b>65.</b> 14	98.76
T16-2	0.43	Ø. 55	34.29	63.39	98.66
T16-3	Ø.57	0.30	48.53	49.59	98.99
T16-4	0.00	Ø.12	43.69	54.70	98.51
T17-1	7.64	4.67	18.18	64.33	94.83
T17-2	Ø. 39	0.50	36.60	61.39	98.88
T17-3	15.80	3.67	26.16	52.89	_ 99.5≳
T17-4	Ø. Ø9	Ø. 37	37.67	60.42	98.55
T18-1	12.96	5.53	10.45	66.60	95.54
T18-2	Ø.74	0.57	34.12	63.10	98.53
T18-3	1.95	1.32	50.69	45.06	99.03
T19-1	1.36	0.61	26.39	69.78	98.14
T19-2	1.48	Ø.78	46.95	49.12	98.32
T20-1	5.82	1.11	49.76	41.89	98.58
T20-2	1.86	0.86	62.95	33.10	98.76

(APPENDIX N

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MARINE CORING

A few sample identification numbers (Sta Id) for marine sediment core samples were changed to fit the database format. These samples may be referred to by a different number in these data sheets than in the text of Volume 1.

10-1-+10 is sample T10-1015 16-0-+10 is sample T16-1012 T2-01 is sample 2-1,2-01

Some station Id. numbers represent QA samples instead of unique stations. These samples are:

10-1-230 is a field duplicated of sample 10-1-23

2-120 is a field duplicate of sample 2-12

7-2-910B was sampled from the second core at station T7-2

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (TOTAL METALS)

Sta Id	Anl	Event	Arsenic ppa	Copper pps	Lead ppm	Zinc ppa
10-1-12	101	MARCORES	62.000	290.000	100.000	343.000
10-1-230	TOT	MARCORES	42.000	390.000	95.000	226.000
10-1015	TOT	MARCORES	13,000	31.000	15.000	62.000
10A-01	TOT	MARCORES	4125.000	11975.000	3450.000	3575.000
10A-12	TOT	MARCORES	4825.000	14500.000	3300.000	3300.000
10A-23	TOT	MARCORES	5500.000	16300.000	3450.000	3575.000
10A-34	TOT	MARCORES	2020.000	5525.000	1685.000	2B00.000
10A-45	TOT	MARCORES	590.000	1850.000	563.000	930.000
10A-7B	TOT	MARCORES	247.000	B13.000	255.000	490.000
13-2-910	TOT	MARCORES	13.000	18.000	11.000	42.000
16-0-+10	TOT	MARCORES	8.500	1B.000	20.000	51.000
2-1,2-01	101	MARCORES	232.000	161.000	230.000	915.000
2-1,2-12	TOT	MARCORES	268.000	223.000	315.000	1208.000
2-1,2-23	TOT	MARCORES	187.000	195.000	253.000	973.000
2-1,2-34	TOT	MARCORES	20.000	22.000	29.000	10B.000
2-1,2-45	TOT	MARCORES	142.000	133.000	196.000	B13.000
2-1,2-78	TOT	MARCORES	22.000	39.000	42.000	212.000
2-120	TOT	MARCORES	242.000	210.000	393.000	1048.000
7-2-1015	TOT	MARCORES	263,000	202.000	310.000	2145.000
7-2-910B	101	MARCORES	126B.000	1358.000	1530.000	3875.000
T10-01	<b>TOT</b>	MARCORES	177.000	550.000	265.000	1268.000
T10-1-23	TOT	MARCORES	57.000	234.000	100.000	300.000
T10-1-34	TOT	MARCORES	17.000	70.000	31.000	100.000
710-1-45	707	MARCORES	37.000	33.000	29.000	93,000
113-2-01	101	MARCORES	26.000	234.000	217,000	2323.000
113-2-12	TOT	MARCORES	42.000	198.000	B2.000	300,000
T13-2-23	TOT	MARCORES	72,000	217.000	93.000	270.000
113-2-34	101	MARCORES	92.000	29.000	22.000	53.000
T13-2-45	TOT	MARCORES	13,000	22.000	31.000	103.000
116-0-01	TOT	MARCORES	700.000	1585.000	B55.000	2338,000
T16-0-12	TOT	MARCORES	247.000	583.000	375.000	945.000

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (TOTAL METALS)

Sta Id	Anl	Event	Arsenic ppm	Copper ppa	Lead pps	Zinc ppm
T16-0-23	TOT	MARCORES	2925.000	1663.000	2B75.000	17800.000
T16-0-34	TOT	MARCORES	2825.000	1378.000	3050.000	19125.000
T16-0-45	TOT	MARCORES	172.000	150.000	253.000	1223.000
T7-2-01	TOT	MARCORES	8725.000	3125.000	4550.000	23650.000
17-2-12	TOT	MARCORES	7675.000	2725.000	4300.000	20875.000
77-2-23	TOT	MARCORES	8775.000	3175.000	4775.000	23075.000
17-2-34	TOT	MARCORES	6225.000	2165.000	3500.000	17500.000
17-2-45	TOT	MARCORES	7900.000	3150.000	4575.000	24400.000

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (EP TOXICITY)

Sta Id	Anl	Event	Arsenic ppa	Cadmium ppm	Chroniun pps	Copper ppm	Lead ppm	Mercury ppb	Selenium ppm	Silver ppm	Zinc ppm	Barium ppo	рН
10-1-+10	EPT	MARCORES	0.067	0.0030<	0.033<	0.036	0.056	0.6000	0.0830<	0.00BO(	0.130	0.50<	8.8
		MARCORES	0.580	0.0050	0.0334	0.017<	0.033(	0.50004	0.0830<	0.00804	0.410	0.504	9.2
		MARCORES	0.050	0.00304	0.033<	0.017<	0.033<	0.50004	0.0830<	0.00804	0.017	0.504	6.3
10A-01		MARCORES	0.280J	0.0200	0.033<	0.017<	0.290	0.50004	0.08304	0.0110	4.600	0.504	7.9
10A-12	EPT	MARCORES	0.310	0.0230	0.033<	0.017<	0.390	0.50004	0.0830<	0.0080<	6.000	0.50<	7.8
10A-23	EPT	MARCORES	0.400	0.0250	0.033<	0.017(	0.270	0.5000{	0.0830<	0.0080<	5.400	0.504	8.1
10A-34	EPT	MARCORES	0.370	0.0220	0.033<	0.017<	0.220	0.50004	0.0830<	0.00804	1.700	0.50<	B.7
10A-45	EPT	MARCORES	0.400	0.0180	0.033<	0.130	0.093	0.5000<	0.0830<	0.00804	1.000	0.50(	8.9
10A-7B	EPT	MARCORES	0.120	0.0080	0.033<	0.520	0.069	0.5000<	0.0B30<	0.0080(	0.460	0.50<	B. 6
13-2-910	EPT	MARCORES	0.023	0.00304	0.033<	0.017<	0.033<	0.5000{	0.0830(	0.0080<	0.017	0.50₹	6.6
16-0-+10	EPT	MARCORES	0.007<	0.0030<	0.033<	0.017<	0.033(	0.50004	0.0830<	0.0080(	5.200	0.50<	B.7
2-1,2-01	EPT	MARCORES	0.033	0.0030<	0.033<	0.017<	0.093	0.50000	0.0B30<	0.0080<	0.980	0.50(	B. 6
•		MARCORES	0.073	0.00304	0.033<	0.017(	0.093	0.5000<	0.0830<	0.00804	1.200	0.50<	8.9
2-1,2-23	EPT	MARCORES	0.050	0.00304	0.033<	0.017<	0.120	0.5000<	0.0830(	0.00804	2.700	0.50<	9.1
2-1,2-34	EPT	MARCORES	0.060	0.00304	0.033<	0.621	0.630	0.5000	0.0630<	0.00804	0.130	0.50{	9.4
		MARCORES	0.057	0.00304	0.033<	0.017<	0.081	0.50004	0.0B30<	0.00804	0.290	0.50<	8.9
2-1,2-78	EPT	MARCORES	0.020	0.00304	0.033<	0.017<	0.033{	0.50004	0.0830<	0.0080<	0.072	0.50<	B.5
2-120		MARCORES	0.0B3	0.0030<	0.033(	0.017<	0.056	0.5000<	0.0B30<	0.0080<	0.560	0.50<	8.B
7-2-1015	EPT	MARCORES	0.610	0.0220	0.033<	0.026	0.044	0.5000<	0.0B30<	0.00804	2.200	0.504	B.9
7-2-910B	EPT	MARCORES	0.190	0.0070	0.033(	0.017<	0.044	0.50004	0.0830<	0.00804	3.700	0.50<	8.4
T10-01	EPT	MARCORES	0.070	0.0030<	0.033<	0.049	0.081	0.50000	0.0B30<	0.00804	0.980	0.50<	B.7
T10-1-23	EPT	MARCDRES	0.130	0.0030<	0.0334	0.0174	0.069	0.5000(	0.0B30<	0.00804	0.160	0.504	9.2
T10-1-34	EPT	MARCDRES	0.013	0.00304	0.0334	0.0174	0.0334	0.5000(	0.0830(	0.0080(	0.040	0.504	9.2
T10-1-45	EPT	MARCORES	0.063	0.0050	0.0334	0.017<	0.033(	0.5000<	0.08304	0.0080<	0.035	0.50<	9.2
T13-2-01	EPT	MARCORES	0.017J	0.0030<	0.033<	0.0174	0.110	0.50004	0.0830<	0.0080<	4.700	0.50<	8.9
713-2-12	EPT	MARCORES	0.053J	0.0030<	0.033<	0.041	0.081	0.5000(	0.0830<	0.00804	0.770	0.50<	9.3
113-2-23	EPT	MARCORES	0.0703	0.00304	0.033(	0.023	0.069	0.50004	0.0830(	0.00804	0.270	0.50<	9.2
		MARCORES	0.0403	0.00304	0.033<	0.0174	0.033<	0.50000	0.0830<	0.0080{	0.035	0.50<	9.5
		MARCORES	0.050	0.00304	0.033<	0.0174	0.044	0.5006<	0.0830(	0.00 <b>80</b> <	0.022	0.50<	9.4
		MARCGRES	0.093	0.0030<	0.033(	0.017<	0.069	0.5000{	0.0830<	0.0080<	1.500	0.50<	B.0
		MARCORES	0.053	0.0030<	0.033<	0.0174	0.069	0.50004	0.0830<	0.00804	1.600	0.50<	7.6
T16-0-23	EPT	MARCORES	0.083	0.0030<	0.033(	0.017<	0.056	0.5000(	0.0830(	0.00804	2.000	0.50<	7.6

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (EP TOXICITY)

			<b>Ģ</b> rsenic	Cadmium	Chronius	Copper	Lead	Mercury	Selenium	Silver	Zinc	Barium	ρH
Sta Id	Anl	Event	рра	ρpa	ppa	ρρa	рра	ppò	ppa	ppa	ppe	₽₽♠	
T16-0-34	EPT	MARCORES	0.070	0.0030<	0.033<	0.0174	0.056	0.50004	0.0B30<	0.0080<	3.800	0.50<	7.5
T16-0-45	EPT	MARCORES	0.007<	0.0030<	0.033<	0.072	0.044	0.50004	0.0830<	0.0080(	4.300	0.50<	8.9
T7-2-01	EPT	MARCORES	0.093J	0.0030<	0.033<	0.640	0.056	0.5000<	0.0830{	0.00804	4.800	0.50<	7.8
77-2-12	EPT	MARCORES	0.066J	0.0030{	0.033<	0.270	0.069	0.5000<	0.0830<	0.0080<	1.800	0.50<	6.3
17-2-23	EPT	MARCORES	0.0303	0.0030<	0.033<	0.200	0.069	0.5000<	0.0830(	0.0080<	1.600	0.50<	5.9
17-2-34	EPT	MARCORES	0.020J	0.0030<	0.033<	0.077	0.044	0.5000<	0.0B30<	0.0080<	1.180	0.50<	7.2
T7-2-45	EPT	MARCORES	0.0373	0.0030{	0.033<	0.110	0.033<	0.50064	0.0830<	0.0080<	2.200	0.50<	6.7

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta Id	Anl Eve	nt	Benzoic Acid ppb	2-Chloro phanol ppb	2.4-Di chlors phenol ppb	2,4-Di methyl phenol ppb	2,4-Di nitro phenol ppb	2-Methyl phenal ppb	4-Methyl phenol ppb
10-01	TOT HAR	CORES	3100.00J	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10-1015	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10-12	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10-23	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
:10-230	TOT HAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10-34	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.0GN	400.00N
10-45	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10A-01	TOT MAR	CORES	4000.00N	700.00N	700.00N	700.00N	4000.00N	700.00N	700.00N
10A-12	TOT MAR	CORES	7000.00N	1000.00N	1000.00N	1000.00N	7000.00N	1000.00N	1000.00N
10A-23	TOT MAR	CORES	20000.00N	3000.00N	3000.00N	3000.00N	20000.00N	3000.00N	3000.00N
10A-34	TOT MAR	CORES	3000.00N	500.00N	500.00N	500.00N	3000.00N	500.00N	500.00N
10A-45	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10A-78	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
10A-7B	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
13-2-12	TOT MAR	CORES	2000.GON	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
13-2-23	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
13-2-34	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
13-2-45	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
13-2-910	TOT MARI	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
16-0-+10	TOT MARI	CORES	2000.00N	400.00N	400.00N	400.00N	2000,00N	400.00%	400.00N
16-0-01	TOT MAR	CGRES :	200000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N
16-0-12	TOT KAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
16-0-23	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
16-0-34	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
16-0-45	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.0CN	400.00N
2-1.2-01	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	510.000
2-1,2-23	TOT MAR	CORES	2000.00N	400,60N	400.00N	400.00N	2000.00N	400.00N	400.00N
2-1,2-34	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.06H
2-1,2-45	TOT MAR	CORES	2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
2-1,2-78	TOT MAR	CORES	2000.00N	400.00N	400.(ON	400.00N	2000.00N	400.00N	400.00N

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta Id	Anl Even	Benzoic Acid t ppb	2-Chloro phenal ppb	2,4-D1 chloro phenol ppb	2,4-DI methyl phenol ppb	7,4-D1 nitro phenol ppb	2-Methyl phenol ppb	4-Methyl phenol ppb
7-2-1015	TOT MARC	DRES 2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
7-2-910B	TOT MARC	BRES 2000.00N	400.00H	400.00N	400.00N	2000.00N	400.0CN	400.00N
7-7-2-01	TOT MARC	DRES 3500.00J	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
T-7-2-12	TOT MARC	DRES 2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
1-7-2-23	TOT MARC	DRES 2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
T-7-2-34	TOT MARC	ORES 2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N
T-7-2-45	TOT MARCE	ORES 2000.00N	400.00N	400.00N	400.00N	2000.00N	400.00N	400.00N

MARINE SEDIMENT SAMPLES - ASARCO SENI-VOLATILES (ACIDS)

Sta Id	Anì	Event	2-Nitro phenol ppb	4-Nitro phenol ppb	4-Chloro- 3-methyl phenal ppb	Fenta chloro phenol ppb	Phenol ppb	2.4,5-Tri chloro phenol ppb	2,4,6-Tri chloro phenol ppb
10-01	TOT	MARCORES	400.00N	2000.00N	400.00N	1000.00N	400.00N	2000.00H	400.00H
10-1015	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
10-12	TOT	MARCORES	400.00N	2000.00N	400.0GN	2000.00N	400.00N	2000.00N	400.00N
10-23	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
10-230	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
10-34	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
10-45	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
10A-01	TOT	MARCORES	700.00N	4000.00N	700.00N	2000.00N	700.00N	4000.00N	700.00N
10A-12	101	MARCORES	1000.00N	7000.00N	1000.00N	3000.00N	1000.00N	7000.00N	1000.00N
10A-23	TOT	MARCORES	3000.00N	20000.00N	3000.00N	B000.00N	3000.00N	20000.00N	3000.00N
10A-34	TOT	MARCDRES	500.00N	3000.00N	500.00N	3000.00N	500.00N	3000.00N	500.00N
10A-45	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
10A-78	TOT	MARCORES	400.00N	2000.00N	400.00N	1000.00N	400.00N	2000.00N	400.00N
10A-7B	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
13-2-12	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
13-2-23	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
13-2-34	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
13-2-45	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00%	400.00N
13-2-910	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
16-0-+10	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
16-0-01	TOT	MARCORES	30000.00N	200000.00N	30000.00N	200000.00N	30000.00N	200000.00N	30000.00N
16-0-12	TOT	MARCGRES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
16-0-23	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00H	400.00N
16-0-34	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00H
16-0-45	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00%	400.0GN
2-1,2-01	TOT	MARCORES	400.00N	2000.00M	400.0CN	2000.00N	400.00N	2000.GON	400.00N
2-1,2-23	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
2-1,2-34	TOT	MARCORES	400.00N	2000.00N	400.00N	2600.00N	400.00N	2000.CON	400.00N
2-1,2-45	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
2-1,2-78	TOT	MARCORES	400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N

MARINE SEDIMENT SAMPLES - ASARCO SEMI-VOLATILES (ACIDS)

Sta Id	Anl Event	2-Nitro phenol ppb	4-Nitro phenol ppb	4-Chloro- 3-methyl phenol ppb	Penta chloro phenol ppb	Phenal ppb	2,4,5-Iri chloro phenol ppb	2,4,6-1ri chloro phenol ppb
7-2-1015	TOT MARCORE	S 400.00N	2000.00N	400.0CN	2000.00N	400.00N	2000.00N	400.00N
7-2-910B	TOT MARCORE	S 400.00N	2000.00N	400.0CN	2000.00N	400.00N	2000.00N	400.00N
1-7-2-01	TOT MARCORE	S 400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.06N
T-7-2-12	TOT MARCORE	S 400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
1-7-2-23	TOT MARCORE	S 400.00N	2000.00N	400.00N	2000.00N	400.GON	2000.00N	400.00N
7-7-2-34	TOT MARCORE	5 400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N
1-7-2-45	TOT MARCORE	S 400.00N	2000.00N	400.00N	2000.00N	400.00N	2000.00N	400.00N

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

			Ace naphthene	Acenaph thylene	Aniline	Anthracse	Benzidine	Benzo(a) anthracne	Penzo(a) pyrene	Benzo(b) fluor anthene	Benzo (g,h,i) perylene	Benzo(k) fluor anthene	Benzyl Alcohol	bis(2-chl oroethoxy )aethane
Sta Id	Aal	Event	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppp	ppb	tbp	bbp
10-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	540.00J	1000.00J	400.00N	400.0GN	400.00N	400.00N
10-1015		MARCORES	400.00N	400.00N	400.0CM	400.00N	3000.00N	400.00N	400.GON	400.00N	400.00N	400.00N	400.00N	460.00N
10-12		MARCORES	400.00N	400.00N	400.00N	400.00N	K00.000E	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	40G.00N
10-230	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	460.00N	400.00N
10-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10A-01	TOT	MARCORES	700.00N	700.00N		B70.00J		1740.00J	1370.00J	700.GON	1590.00J	700.00N	700.00N	700.00N
10A-12	TOT	MARCORES	1000.00N	1000.00N		1000.00N		1500.00J	1000.00N	2700.00J	1000.00N	1000.00N	1000.00N	1000.00N
10A-23	101	MARCORES	3000.00N	3000.00N		3000.00N		3000.00M	3000.00N	£300.00J	3000.00N	3000.00N	3000.00N	3000.00N
10A-34	TOT	MARCORES	500.00N	500.00N	500.00N	500.00N	4000.00N	670.003	1460.00J	2710.00J	500.00N	500.00N	500.00N	500.00N
10A-45	101	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10A-7B	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.0GN	400.00N	, 400.00N	400.00N	400.00N	400.00N
10A-78	TOT	MARCDRES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-45	TOT	KARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-910	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
14-0-+10	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
16-0-01	101	MARCORES	30000.00N	30000.00%		30000.00N		30000.0CN	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N
16-0-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	11B0.00J	920.00J	1930.00J	480.00J	K00.00X	400.0CN	400.00N
16-0-23	TOT	MARCORES	400.00N	400.00H	400.00N	400.00N	3000.00N	840.003	720.00J	1600.003	570.00J	400.00N	400.00N	400.00N
16-0-34	TOT	MARCDRES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
16-0-45	101	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-01	101	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-23	TOT	MARCURES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.001	400.00X
2-1,2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.0GN	400.00N	400.0CN	400.00N	400.00N	400.00N
2-1,2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-78	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.0CM	400.00N	400.00N	400.00N	400.00%	400.00N	400.00N

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	Ace naphthene ppb	Acenaph thylene ppb	Aniline ppb	Anthracne ppb	Benzidine ppb	Benzo(a) anthracne ppb	Benzo(a) pyrene ppb	Benzo(b) fluor anthene ppb	Benzo (g,h,i) perylene ppb	Henza(k) fluor anthene ppb	Benzyl Alcohol ppb	bis(2-chl oroethoxy )methane pab
7-2-1015	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.0GN	400.GON	400.00N
7-2-910B	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-01	707	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-12	TOT	MARCGRES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.GON	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-34	TOT	MARCGRES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	3000.00N	400.0GN	400.00N	400.0CM	400.00N	400.00N	400.0CM	400.00N

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

			bis(2-chl oroethyl)	bis(2-chl orpisopro	bis(2-eth ylhexyl)	4-Bromoph enyl-phen	Butył benzyl	4-Chloro	2-Ehloro	4-Chlorop henyl phe		Dibenzo (a,h)	Dibenzo	1,2- Dicloro
			ether	pyllether	phthalate	yl ether	phthalate	aniline	naphthlne	nyl ether	Chrysene	anthracne	furan	benzene
Sta Id	Anl	Event	ppb	ррь	ppb	ppb	ppb	ppb	ppb	ppb	ърр	ppb	ppb	ppb
10-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10-1015	TOT	MARCDRES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	409.00N
10-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10-230	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10-34	101	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0GN	400.00N
10-45		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.GON	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10A-01	TOT	MARCORES	700.00N	700.00N	1090.00J	700.00N	700.00N	700.00N	700.00N	700.00N	2240.00J	700.00N	700.00N	700.00N
10A-12	TOT	MARCORES	1000.00N	1000.00N	7200.00J	1000.00N	2500.00J	1000.00N	1000.00N	1000.00N	2500.00J	1000.00N	1000.00N	1000.00N
10A-23	101	MARCORES	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	5300.00J	3000.00N	3000.00N	3000.00N
10A-34	TOT	MARCORES	500.00N	500.00N	500.00N	500.00N	500.00N	500.00N	500.00N	500.00N	990.00J	500.00N	500.00N	500.GON
10A-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10A-7B	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
10A-78	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	460.00N	400.00N
13-2-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400,00N	400.00N	400.00N	400.00N	400.00N	400.0GN	400.00N
13-2-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.0GN	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-910	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
16-0-+10	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
16-0-01	TOT	MARCORES	30000.00N	30000.00N	30000.00N	30000.00N	30000.06N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N
16-0-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	1830.00J	400.00N	400.00N	400.00N
16-0-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	1530.00J	400.00N	400.0GN	400.00N
16-0-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
16-0-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-01	TOT	HARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-23	TOT	<b>MARCORES</b>	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.06N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
•		MARCORES	400.00N	400.00N	480.003	400.00N	400.000	400.00N	400.00N	460.00N	400.00N	400.00N	400.00N	400.00N
•		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	KO0.004	400.00N	400.00N	400.0 <b>0</b> M

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

OL - 14	A-1	Forest	bis(2-chl oroethyl) ether	bis(2-chl oroisopro pyl)ether	bis(2-eth ylhexyl) phthalate	4-Brocoph enyl-phen yl ether	Butyl . benzyl phthalate	4-Chloro aniline	2-Ehloro naphthlne	4-Chlorop henyl phe nyl ether	Chrysene	Dibenzo (a,h) anthracne	Dibenzo furan	1,2- Dicloro benzene
Sta Id	HUI	Event	ррь	bbp	ppb	ppb	ppb		ppb	ррь	ppb	ppa	ppb	ppb
7-2-1015	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
7-2-9108	TOT	MARCORES	400.00N	400.00N	400.00N	400.GON	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
7-7-2-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CN
T-7-2-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CH	400.00N
T-7-2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0GN	400.00N

Farametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

			Hexa 'chloro	Hexachlor ocyclopen	Hexa chloro	Indeno (1,2,3-cd	Iso	2-Methyl		2-Nitro	3-Nitro	4-Hitro	Nitro	N-Nitroso dimethyl
		•	but adi ene	tadiene	ethane	Pyrene	phorone	naphthlne	Naphthlne	aniline	aniline	aniline	benzene	anine
Sta Id	Anl	Event	ppb	ppb	ppb	ррь	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
10-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2009.00N	2000.00N	2000.00N	400.00N	400.00N
10-1015	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
10-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0 <b>0</b> N	2000.00N	2000.00N	2000.00N	400.60N	400.00N
10-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.0GN	400.00N
10-230	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CN	2000.00N	2000.00N	2000.00N	400.00N	400.00N
10-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
10-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
10A-01	TOT	MARCORES	700.00N	700.00N	700.00N	700.0CN	700.00N	700.GON	700.00N	4000.00N	4000.00N	4000.00N	700.00N	
10A-12	TOT	MARCORES	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N	2900.00J	1000.00N	7000.00N	7000.00N	7000.00N	1000.05N	
10A-23	TOT	MARCORES	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	20000.00N	20000.00N	20000.00N	3000.00N	
10A-34	TOT	MARCORES	500.00N	500.00N	500.00N	670.00J	500.00N	4200.00J	500.00N	3000.00M	3000.00N	3000.00N	500.00N	500.00N
10A-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
10A-78	TOT	MARCORES	400,00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
10A-78	TOT	MARCDRES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CN	2000.00N	2000.00N	2000.00N	400.00N	400.00N
13-2-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
13-2-23	TOT	MARCORES	400.00N	400.00N	400.0CM	400.00N	400.00N	490.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
13-2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000,00N	2000.00N	2000.00N	400.00N	400.00N
13-2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
13-2-910	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
16-0-+10	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
16-0-01	TOT	MARCORES	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	200000.00N	200000.00N	200000.00N	30000.00N	
16-0-12	TOT	MARCORES	400.00N	400.00N	460.00N	430.00J	400.00N	400.00N	400.00N	2000,00N	2000.00N	2000.00N	400.00N	400.00N
16-0-23	TOT	MARCORES	400.00N	400.00N	400.00N	450.00J	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
16-0-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00M	400.00N	400.00N	400.00N	2000.00N	2009.00N	2000.00N	400.00N	400.00N
16-0-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
2-1,2-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000,00N	2000.00N	2000.00N	400.00N	400.00N
•		MARCORES	400,00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000,008	2000.00N	2000.0GN	406.00N	400.00N
•		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	460.00N	400.00N	2000.00N	2000.00N	2000.0011	400.00N	400.00N
		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	409.00N	400.00N
•		MARCGRES	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N

Paragetrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl Event	Hexa chloro butadiene ppb	Hexachlor ocyclopen tadiene ppb	Hexa chloro ethane ppb	Indeno (1,2,3-cd Pyrene ppb	Iso phorone ppb	2-Methyl naphthine ppb	Kaphthlne ppb	2-Nitro aniline ppb	3-Nitro aniline ppb	4-Nitro aniline ppb	Mitro benzene ppb	N-Nitroso dimethyl amine ppb
7-2-1015	TOT MARCO	RES 400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
7-2-9108	TOT MARCO	RES 400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
1-7-2-01	TOT MARCE	RES 400.00N	400.00N	400.00N	400.00N	400.00N	590.00J	660.003	2000.00N	2000.00N	2000.00N	400.00N	400.00N
T-7-2-12	TOT MARCE	RES 400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
1-7-2-23	TOT MARCO	RES 400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
1-7-2-34	TOT MARCE	RES 400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N
1-7-2-45	TOT MARCO	RES 400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2000.00N	2000.00N	2000.00N	400.00N	400.00N

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

		1,3-	1,4-	3,3'-	B	m· 11 1	Di-n-	2,4-	2,6-	Di-n-	<b>5</b> 1		Hexa
		Dichloro	Dichloro	Dichloro	Diethyl	Dimethyl	Butyl	Dinitro	Dinitro	Octyl	Fluor	<b>71</b>	chloro
C4 - 14	Anl Event	benzene	benzene	benzidine	phthalate	phthalate	phthalate	toluene	toluene	Phthalate	anthene	Fluorene	benzene
Sta Id	HIII EVENT	ppb	ppb	ppb		ppb	ppb	ppb	ppb	ppb	ppb	 ენ <b>р</b>	ppb
10-01	TOT MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N						
10-1015	TOT MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N						
10-12	TOT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N						
10-23	TOT MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N	400.00N	400.30N	400.00N	420.00J	400.00N	400.00N
10-230	TOT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N						
10-34	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N						
10-45	TOT MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N						
10A-01	TOT MARCORES	700.00N	700.00N	1000.00N	700.00N	700.00N	700.00H	700.00N	700.00N	700.00N	3330.001	700.00N	700.00N
10A-12	TOT MARCORES	1000.00N	1000.00N	3000.00N	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N	1000.00N	4500.00J	1000.00N	1000.0 <b>0N</b>
10A-23	TOT MARCORES	3000.00N	3000.00N	6000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	3000.00N	7100.00J	3000.00N	3000.00N
10A-34	TOT MARCORES	500.00N	500.00N	1000.00N	500.00N	500.00N	500.00N	500.00N	500.00N	500.00N	1610.00J	500.00N	500.00N
10A-45	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.0CM	400.00N						
10A-7B	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N						
10A-78	TOT MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N						
13-2-12	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CN	400.00N	400.0CN
13-2-23	TOT MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N						
13-2-34	TOT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N						
13-2-45	TOT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N						
13-2-910	TOT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N						
16-0-+10	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N						
16-0-01	TOT MARCORES	30000.00N	30000.00N	60000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	30000.00N	36000.00J	30000.00N	30000.00N
16-0-12	TOT MARCORES	400.00N	400.00N	900.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	3150.00J	400.00N	400.00N
16-0-23	TOT MARCORES	400.0GN	400.00N	B00.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	2450.00J	400.00N	400.GON
16-0-34	TOT MARCGRES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N						
16-0-45	TOT MARCORES	400.00N	400.00N	900.00N	400.00N	400.00N	400.00N						
2-1.2-01	TOT MARCORES	400,00N	400.00N	900.00N	400.00N	400.00N	400.00M	400.00N	400.06N	400.00N	400.00N	400.00N	400.00N
•	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00%	490.00N	400.00N		400.00N	400.00N	400.CON
•	TOT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	406.00N	400,00N	400.00N	400.00N	400.00N	490.00N	400.00N
•	TOT MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N						
	TOT MARCORES	400.00N	400.0CN	800.00N	400.00N	400.00N	400.00N						

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

		1,3- Dichloro benzene	1,4- Dichloro benzene	3,3'- Dichloro benzidine	Diethyl phthalate	Dimethyl phthalate	Di-n- Butyl phthalate	2,4- Dinitro toluene	2,6- Dinitro toluene	Di-n- Octyl Phthalate	Fluor anthene	Fluorene	Hexa chloro benzene
Sta Id An	1 Event	ррь	ppp	ppb	ppb	ppb	ppb	ppb	ррв	ppb pp	ppb	ppb	dqq
7-2-1015 TO	T MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.0CN	400.00N	400.00N
7-2-910B TO	T MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.GON	400.GON	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-01 TD	T MARCORES	400.00N	400.00N	800.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-12 TO	T MARCORES	400.00N	400.00N	B00.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-23 TO	IT MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-34 TO	T MARCGRES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-45 TO	T MARCORES	400.00N	400.00N	700.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N	400.00N

Parametrix Inc. -- Environmental Data System
MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	N-Nitroso dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Phen anthrene ppb	Pyrene ppb	1,2,4-Tri chloro benzene ppb
10-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10-1015	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10-12		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10-23		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10-230	101	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10-45		MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10A-01	101	MARCORES	700.00N	700.00N	4070.00J	3550.00J	700.00N
10A-12	TOT	MARCORES	1000.00N	1000.00N	1500.00J	4900.00J	1000.00N
10A-23	TOT	MARCORES	3000.00N	3000.00N	3000.00N	7600.00J	3000.00N
10A-34	TOT	MARCORES	500.00N	500.00N	1250.00J	2660.00J	500.00N
10A-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10A-78	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
10A-7B	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	460.00N
13-2-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
13-2-45	TDT	MARCORES	400.00N	400.00N	400.00H	400.00N	400.00N
13-2-910	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
16-0-+10	TOT	MARCORES	400.00N	400.00N	400.60N	400.00N	400.00N
16-0-01	TOT	MARCORES	30000.00N	30000.00N	36000.00J	30000.0GN	30000.00N
16-0-12	TOT	MARCORES	400.00N	400.00N	3930.003	3540.003	400.00N
16-0-23	TOT	MARCORES	400.00N	400.00N	2860.00J	2570.00J	400.00N
16-0-34	TOT	MARCORES	400.00N	400.00N	400.00N	460.00N	400.00N
16-0-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-23	701	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
2-1,2-78	101	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N

Parametrix Inc. -- Environmental Data System MARINE SEDIMENT SAMPLES - (BASE NEUTRALS)

Sta Id	Anl	Event	N-Nitroso dipropyl amine ppb	N-Nitroso diphenyl amine(1) ppb	Phen anthrene ppb	Pyrene ppb	1,2,4-Tri chloro benzene ppb
7-2-1015	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
7-2-910B	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-01	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-12	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
1-7-2-23	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-34	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N
T-7-2-45	TOT	MARCORES	400.00N	400.00N	400.00N	400.00N	400.00N

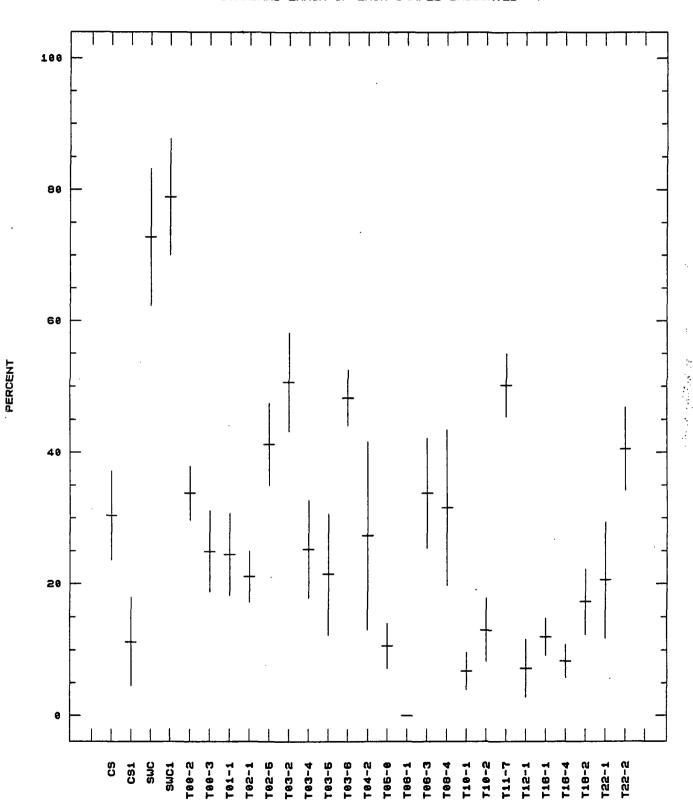
APPENDIX O

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BIOASSAY

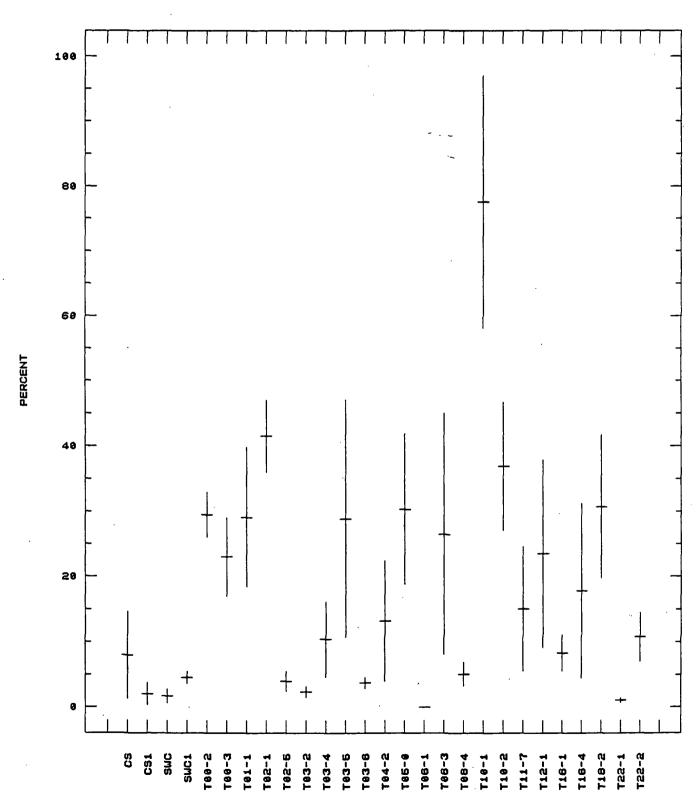
#### PERCENT OF LARVAE SURVIVING

#### STANDARD ERROR OF EACH SAMPLE INDICATED



#### PERCENT OF LARVAE THAT ARE ABNORMAL

#### STANDARD ERROR OF EACH SAMPLE INDICATED



# Asarco Marine Amphipod Bioassay Results

\* - sample deleted due to lack of aeration.

		Survivors	Average	Percent Surviv	/al
0 -2 0 -2 0 -2 0 -2 0 -2	1 2 3 4 5	18 20 18 18 19	18.6	93.0%	
0 -3 0 -3 0 -3 0 -3 0 -3	1 2 3 4 5	17 13 18 6 17	14.2	71.0%	
1 -1 1 -1 1 -1 1 -1 1 -1	1 2 3 4 5	19 18 20 17 20	18.8	94.0%	-
2 -1 2 -1 2 -1 2 -1 2 -1	1 2 3 4 5	20 18 20 19 19	19.2	96.0%	·
2 -5 2 -5 2 -5 2 -5 2 -5	1 2 3 4 5	18 17 16 16 14	16.2	81.0%	
3 -2 3 -2 3 -2 3 -2 3 -2	1 2 3 4 5	18 1 * 17 16 18	14 17.25	70.0% 86.25	
3 -4 3 -4 3 -4 3 -4 3 -4	1 2 3 4 5	16 19 15 19 17	17.2	86.0%	
3 ~5 3 ~5 3 ~5 3 ~5 3 ~5	1 2 3 4 5	12 13 9 15 1 *	10 12.25	50.0% 61.25	
3 -6 3 -6 3 -6 3 -6 3 -6	1 2 3 4 5	18 0 * 19 20 20	15.4 19.25	77.0% 96.25	
4 -2	1	7	10.2	51.0%	

4 -2 4 -2 4 -2 4 -2	2 3 4 5	6 11 13 14		
5 -0 5 -0 5 -0 5 -0 5 -0	1 2 3 4 5	20 19 19 19 14	18.2	91.0%
6 -1 6 -1 6 -1 6 -1 6 -1	1 2 3 4 5	2 0 1 0	0.6	3.0%
6 -3 6 -3 6 -3 6 -3	1 2 3 4 5	18 19 13 14 14	15.6	78.0%
8 -4 8 -4 8 -4 8 -4	1 2 3 4 5	18 16 17 16 16	16.6	83.0%
10 -1 10 -1 10 -1 10 -1 10 -1	1 2 3 4 5	16 18 20 17 15	17.2	86.0%
10 -2 10 -2 10 -2 10 -2 10 -2	1 2 3 4 5	20 19 18 19 17	18.6	93.0%
11 -7 11 -7 11 -7 11 -7 11 -7	1 2 3 4 5	20 20 19 20 17	19.2	96.0%
12 -1 12 -1 12 -1 12 -1 12 -1	1 2 3 4 5	10 7 9 7 5	7.6	38.0%
16 -1 16 -1 16 -1 16 -1 16 -1	1 2 3 4 5	19 19 17 20 20	19	95.0%
16 -4	1	18	16.6	83.0%

16	-4	2	16		
16	-4	3	15		
16	-4	4	14		
16	-4	5	20		
18	-2	1	20	17.2	86.0%
	-2	2	16		
	-2	3	18		
	-2	4	17		
18		5	15		
10	-			•	
22	-1	1	16	18.2	91.0%
22		2	19		
	-1	3	18		
	-1	4	20		
22		5	18		•
22	-•	•			
22	-2	1	14	15	75.0%
	-2	2	14		
	-2	3	14		
	-2 -2	4	15		
		5	18		
22	-2	9	10		

Amphipod Bicassay Summary Table

		Total	Percent		
Sample	Replicate	Survival	Survival	Mean	STD
=======	=========		=======		========
CS	5	19	95	99.00	2.00
CS1	5	20	100	98.00	4.00
T00-2	5	19	95	93.00	4.00
T00-3	5	17	85	71.00	22.23
T10-1	5	15	75	86.00	8.60
T10-2	5	17	85	93.00	5.10
T11-7	5	17	85	96.00	5.83
T12-1	5	5	25	38.00	8.72
T16-1	5	20	100	95.00	5.48
T16-4	5	20	100	83.00	10.77
T18-2	5	15	75	86.00	8.60
TØ1-1	5	20	100	94.00	5.83
T22-1	5	18	90	91.00	6.63
T22-2	5	18	90	75.00	7.75
T02-1	5	19	95	96.00	3.74
T02-5	5	14	70	81.00	6.63
TØ3-2	5	18	90	86.25	4.15
T03-4	5	17	85	86.00	8.00
TØ3-5	5			61.25	10.83
TØ3-6	5	20	100	96.25	4.15
TØ4-2	5	14	70	51.00	15.94
T05-0	5	14	70	91.00	10.68
TØ6-1	5	Ø	Ø	3.00	4.00
T06-3	5	14	70	78.00	12.08
TØ8-4	5	16	80	83.00	4.00

								<del>-</del> .
			Y - OYSTE				_	
7	/16/88	Contro	l counts		SWC=Sea wa			<u> </u>
	<b>—</b>	_		Percent	0.5	Percent	Total	Percent
	Sample	Rep.	Normal	Normal		Abriormal		Survival
	T5-0	1	17	62.96	10	37.04	27	13.24
	T5-0	5	32	47.06	36	52.94	68	33.33
	T5-0	3	32	53.33	28	46.67	60	29.41
	T5-0	4	36	48.00	39	52.00	75 	36.76
	T5-0	5	28	43.75	36	56.25	64	31.37
	T10-1	1	1	4.00	24	96.00	25	12.25
	T10-1	2	0	0.00	7	100.00	7	3.43
	T10-1	3	2	11.11	16	88.89	18	8.82
	T10-1	4	1	2.70	36	97.30	37	18.14
	T10-1.	5	5	22.22	7	77.78	9	- 4.41
	T10-2	1	7	38.89	11	61.11	18	8.82
	T10-2	2	15	41.67	21	58.33	36	- 17.65
	T10-2	3	7	46.67	8	<b>5</b> 3.33	15	7.35
	T10-2	4	3	42.86	4	57.14	7	3.43
	T10-2	5	1	12.50	7	87.50	8	3.92
	T11-7	1	54	93.10	4	6.90	58	28.43
	T11-7	2	48	97.96	1	2.04	49	24.02
	T11-7	3	100	95.24	5	4.76	105	51.47
	T11-7	4	47	90.38	5	9.62	52	25.49
	T11-7	5	62	93.94	4	6.06	66	32.35
	T12-1	1	1	8.33	11	91.67	12	5.88
	T12-1	2	Ø	0.00	8	100.00	8	3.92
	T12-1	3	3	3.41	85	96.59	88	43.14
	T12-1	4	2	6.06	31	93.94	33	16.18
	T12-1	5	2	8.70	. 21	91.30	23	11.27
	T16-1	1	39	61.90	24	38.10	63	30.88
	T16-1	٤	33	42.31	45	57.69	78	38.24
	T16-1	3	23	71.88	9	28.13	32	15.69
	T16-1	4	28	54.90	23	45.10	51	25.00
	T16-1	5	25	38.46	40	61.54	65	31.86
	T16-4	1	5	14.29	30	85.71	35	17.16
	T16-4	2	3	10.00	27	90.00	30	14.71
	T16-4	3	2	100.00	_· Ø	0.00	2	0.98
	T16-4	4	5	8.20	56	91.80	61	29.90
	T16-4	5	5	20.00	20	80.00	25	12.25
	T18-2	1	3	11.11	24	88.89	27	13.24
	T18-2	2	7	7.53	86	92.47	93	45.59
	T18-2	3	2	100.00	Ø	0.00	23	Ø. 98
	T18-2	4	1	3.85	25	96.15	26	12.75
	T18-2	5	6	27.27	16	72.73	55	10.78
	SWC	1	97	98. 98	1	1.02	98	48.04
	SWC	2	179	99.44	1	Ø. 56	180	88.24
	SWC	3	210	99.06	5	Ø. 94	212	103.92
	SWC	ے 4	190	97.94	4	2.06	194	95.10
	SWC	5	147	99.32	1	Ø. 68	148	72.55
	3WC	J	14/	99. SE		e. 55	170	/ C. J.J

ASARACO	BIOASS	SAY - DYS	TERS				
8/11/88	Contr	ol count	s=235	CS=Control	sediment	SWC=Sea wate	r control
		-	Percent		Percent	Total	Percent
Sample	Rep.	Normal	Normal	Abnormal	Abnormal	Survival	Survival
CS	1	15	65.22	8	34.78	23	9.79
CS	2	92	100.00	Ø	0.00	92	39.15
CS	3	86	97.73	2	2.27	88	37.45
CS	4	106	97.25	3	2.75	109	46.38
CS	5	45	100.00	Ø	0.00	45	19.15
TØ-2	1	66	68.04	31	31.96	97	41.28
TØ-2	2	52	73.24	19	26.76	71	30.21
TØHE	3	49	58.33	35	41.67	84	35.74
TØ-2	4	34	73.91	12	26.09	46	19.57
TØ-2	5	78	78.79	21	21.21	99	42.13
TØ-3	1	10	76.92	3	23.08	13	5.53
TØ-3	2	92	92.00	8	8. ଉପ	1 ଉପ	42.55
TØ-3	3	43	55.13	35	44.87	78	33.19
TØ-3	4	40	78.43	11	21.57	51	21.70
TØ-3	5	42	82.35	Э	17.65	51	21.70
T1-1	1	72	81.82	16	18.18	88	37.45
T1 - 1	2	73	83.91	14	16.09	87	37.02
T1-1	3	39	76.47	12	23.53	<b>5</b> 1	21.70
T1-1	4	2	28.57	5.	71.43	7	2.98
T1-1	5	46	83.64	9	16.36	55	23.40
T2-1	· 1	26	61.90	16	38.10	42	17.87
T2-1	2	35	51.47	33	48.53	68	28.94
T2-1	3	53	70.67	55	29.33	75	31.91
T2-1	4	21	67.74	10	32.26	31	13.19
T2-1	5	13	40.63	19	59.38	32	13.62
T5-0	1	3	100.00	Ø	0.00	3	1.28
T5-0	2	3	30.00	7	70.00	10	4.26
T5-Ø	3	34	77.27	10	22.73	44	18.72
T5-0	4	55	78.57	6	21.43	28	11.91
T5-Ø	5	25	62.50	15	37.50	40	17.02
	_						
T10-1	1	Ø	0.00	Ø	0.00	Ø	0.00
T10-1	ž	1	9. 09	10	90.91	11	4.68
T10-1	3	Ø	0.00	S	100.00	5	2.13
T10-1	4	Ø	0.00	34	100.00	34	14.47
T10-1	5	1	3.33	29	96.67	30	12.77

ASARACO	BIOASS	SAY - OYS	TERS	•			
8/11/88	Contr	rol counts	s=235	CS=Control	sediment	SWC=Sea wate	r control
			Percent		Percent	Total	Percent
Sample	Rep.	Normal	Normal	Abriorma1	Abnormal	Survival	Survival
T10-2		22	88.00	3	12.00		10.64
T10-2		3	30.00		70.00		4.26
T10-2	3	26	55.32		44.68	47	20.00
T10-2		49	75.38	16	24.62	65	27.66
T10-2	5	4	66.67	2	33. 33	6	2.55
T11-7		49	48.04	53	51.96		43.40
T11-7	2	86	84.31	16	15.69	102	43.40
T11-7	3	158	97.53	4	2.47	162	68.94
T11-7	4	107	98.17	2	1.83	109	46.3B
T11-7	5	111	96.52	4	3.48	115	48.94
T12-1	1	17	41.46	24	58.54		17.45
T12-1	2	18	40.91	26	59.09	44	18.72
T12-1	3	Ø	0.00	2	ଉ. ଉଉ	Ø	ଫ.ଡଡ
T12-1	4	Ø	ଉ.ଅଡ	Ø	ଡ.ଡଥ	Ø1	ପ. ପଥ
T12-1	5	Ø	Ø. ØØ	Ø	ହ. ହହ	Ø	ଉ. ଉଷ
T16-1	1	29	85.29	5	14.71	34	14.47
T16-1		34	91.89	3	8.11	37	15.74
T16-1		6	85.71	1	14.29	7	2.98
T16-1		19	100.00	Ø	0.00		8.09
T16-1	5	42	95. 45	2	4.55	44	18.72
T16-4		24	100.00	Ø	0.00	24	10.21
T16-4		39	97.50	1	2.50	40	17.02
T164		3	30.00	7	70.00	10	4.26
T16-4		5	83.33	1	16.67	6	2.55
T16-4	5	18	1,00.00	Ø	0.00	18	7.66
T18-2		20	28.57	50	71.43	70	29.79
T18-2	<u> </u>	63	95.45	3	4.55	66	28.09
T18-2	3	17	73.91	6	26.09	23	9.79
T18-2	4	8	72.73	3	27.27	11	4.68
T18-2	5	25	75.76	8	24.24	33	14.04
SWC	1	171	98.28	3	1.72	174	74.04
SWC	2	138	100.00	0	ଡ. ଉଡ	138	58.72
SWC	3	- 204	94.01	13	5.99	217	92.34
SWC	4	97	100.00	0	0.00	<del>9</del> 7	41.28
SWC	5	227	99.13	2	0.87	229	97.45

APPENDIX P

BENTHOS

The benthic data in this section consists of 5 replicates for each station. These replicates are referred to by the station number and suffixes A thru E. The the sixth column in each group is the total for the 5 replicates.

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-E T2-5-T01	r t3-5-a	T3-5-B	T3-5-C	T3-5-D	T3-5-E	T3-5-TOT
Porifera sp. Indet.	8	0	0	6	(		0	. 0	0	:	
Cnidaria sp. Indet.	8	. 8	. 8	8	(	8	8	. 8	9	8	8
Hydroida (encrusting) sp. Indet.	0	0	9	0		8 8	8	8	0	. 0	0
Obelia sp. Indet.	0	9	8	8		9 9	0	8	1	0	1
Sertulariidae sp. Indet.	9	9	1	0	1	1 0	0	8	0	0	0
Thuiaria sp. Indet.	0	1	8	8	1	1 0	•	0	8	2	2
Plumulariidae sp. Indet.	•	0	0	8		9	0	٠ 8	8	0	0
Anthozoa sp. Indet.	8	6	8	8	(	3 0	8	8	1	1	5
Pachycerianthus fimbriatus	1	1	6	0	í	2 8	8	0	1	1	2
Halcampa decemententaculata	8	8	8	1	1		0	0	8	1	1
Platyhelminthes	9	8	0	0	(	9	•	8	6	0	0
Polycladida sp. Indet.	8	0	9	8	(	8 0	•	0	1	0	1
Kronborgia pugettensis	1	0	8	8	1	l 9	0	0	1	0	1
Turbellaria-Kalyptorhynchia sp. Indet.	9	0	8	8	(	3 6	0	8	8	1	1
Nemertea sp. Indet.	1	1	1	1	4	• 0		1	1	8	. 2
Tubulanus sp. Indet.	9	9	8	0		9	•	0	8	0	0
Cerebratulus sp. 1.	0	0	1	0	1	. 0	0	8	2	0	2
Lineus sp. Indet.	0	0	0	8	•	8	0		1	8	1
Micrura sp. Indet.	9	0	0	9		9	8	0	8	0	0
Nemertea-Enopla sp. Indet.	9	9	9	9			8	8	0	0	0
Amphiporus sp. Indet.	0	0	2	0	ä	2 1	0	0	9	0	1
Newatoda sp. Indet.	9	V		9			9	8		0	v
Polynoidae sp. Indet.	V	U	1	v	1		8	U	5	2	4
Halosydna brevisetosa			8	V		8 6	8	· ·	9	6	8
Harmothoe sp. Indet.	2		0		ě	2 0	0	0	U	¥	V
Harmothoe imbricata	1	V			1		9	U		V	U
Harmothoe nr. H. lunulata							9	v			ð
Lepidonotus squamatus	<u>د</u>	1	1	ð			V	8		1	6
Lepidasthenia longicirrata	0	8	U				V	1	0		1
Tenonia kitsapensis	•		•	•				0	28	<b>v</b>	54
Pholoides aspera Pholoe minuta		3	a a	<b>v</b>	15	J 6	3		<b>20</b>	4	
Sthenelais berkeleyi	•	4	•	•			9	4	0 A	a	7
Sthemelais tertiaglabra	Δ	<b>a</b>	Δ.	Φ		, ,	4	4		<b>0</b>	
Paleonotus bellis	4	<b>0</b>	4	4			9	4	4	4	a
Phyllodocide sp. Indet.	1	o o	Δ	Δ	•		<b>υ</b>	4	Δ	A	a
Phyllodoce sp. Indet.	7	4	υ 0.	Δ		. •	<b>U</b>	Δ	ů.	a a	. ด
Phyllodoce groenlandica	v o	1	Δ	Δ	•	1 0	4	a a	2	2	4
Phyllodoce mucosa	4	9	4	Δ		. О	4	a	<u>a</u>	Ω	ā
Eteone sp. Indet.	Φ Δ	9	Φ	<b>0</b>	,	2 2	4	<b>a</b>	. 8	a	Ď.
Eteone californica	a	0	۵	۵	,	8.0	8	a	. 8	À	Ď
Lecone Lailfornica	•	U	•	•		.0	•	Ð	•	•	

ASARCO STATIONS - RAW BIOLOGICAL DATA	T4 2 0	74 2 D	T4 2 C	74 A B	71 0 5	T/ 0 TOT	77. 3. 4	<b></b>				
TAXON NAME	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-8	T6-3-C	T6-3-D	T6-3÷E 	T6-3-TOT
Porifera sp. Indet.	10	. 6	0	5	8	23.	0	8	0	0	8	8
Cnidaria sp. Indet.	1	. 8	1		8	2	0	9		8	9	9
Hydroida (encrusting) sp. Indet.	8	8		•	8	0	0	0	. 0	8	0	8
Obelia sp. Indet.	8	8	•	8	8	0	8	ı	2	8	9	3
Sertulariidae sp. Indet.	4	1	1	1	1	8	8	. 0	8	0	0	8
Thuiaria sp. Indet.	. 8	0	8	. 6	8	8	0	2	0		0	5
Plumulariidae sp. Indet.	16	5	6	16	15	58	8	0		Ģ	8	0
Anthozoa sp. Indet.	8	9	•	0	9	8	1	1	. 2	٠ 6	8	10
Pachycerianthus fimbriatus	8	8	8	8	8	8	1	8	8	8	4	5
Halcampa decemententaculata	1	ė	0	1	1	3	8	. 6	•	•	8	0
Platyhelminthes	· 1	1	i	,, 8	0	3	8	8	1	0	0	1
Polycladida sp. Indet.	8	8	8	: 8	8	8	0	9		8	8	9
Kronborgia pugettensis	11	3	i	8	13	36	8	9	9	8	8	8
Turbellaria-Kalyptorhynchia sp. Indet.	8	0	0		8	0	9	0	8	0	8	0
Nemertea sp. Indet.	1	8	1	1	8	3	0	2	4	2	9	8
Tubulanus sp. Indet.	2	0	8	ė	8	5	9	ē	0	1	8	1
Cerebratulus sp. 1.	0	8	0	•	0	8	1	1	1	1	0	4
Lineus sp. Indet.	2	0	9	3	1	6	9	9	8	8	9	8
Micrura sp. Indet.	1	1	•	8	0	2	2	1	0	1	8	4
Nemertea-Enopla sp. Indet.	0	8	9	1	8	1	1	9	0	0	. 8	1
Amphiporus sp. Indet.	8	8	8	ė	8	8	8	8	0	9	8	0
Nematoda sp. Indet.	6	8	0	1	9	1	9	0	8	8	8	9
Polynoidae sp. Indet.	48	23	26	38	31	166	5	5	7	7	5	23
Halosydna brevisetosa	8	8	Ģ	0	9	0	8	1	8	0	0	1
Harmothom sp. Indet.	0	8	Ģ	0	0	8	0	9	è	0	. 8	0
Harmothoe imbricata	8	. 6	Ģ	8	8	8	8	0	1	9	8	1
Harmothoe nr. H. lunulata	0	8	8	0	8	6	0		9	8	Ģ	0
Lepidonotus squamatus	11	1	8	7	7	26	5	1	0	7	9	10
Lepidasthenia longicirrata	8	1	1	•	8	2	1	1	0	1	9	3
Tenonia kitsapensis	8	0	8	0	0	8	0	8	•	0	0	0
Pholoides aspera	327	179	101	241	328	1176	9	29	24	11	. 0	73
Pholog minuta	8	3	0	8	i	4	8	9	9	8	9	0
Sthenelais berkeleyi	8	8	8	8	8	8	8	8	8	1	8	1
Sthenelais tertiaglabra .	. 8	0	8	8	9	6	0	0	9	8	8	8
Paleonotus bellis	8	0	0	0	8	0	0	0	9	. 0	8	9
Phyllodocide sp. Indet.	1	9	0	1	0	2	1	0	1	1	3	6
Phyllodoce sp. Indet.	8	0	0	1	0	1	8	0	8	8	8	8
Phyllodoce groenlandica	0	0	8	0	0	8	0	0	1	9	8	1
Phyllodoce mucosa	0	0	0	0	0	0	2	5	2	7	0	16
Etoopo en Indot	α.	a	a	a	•	•	a	a	•	a	Δ.	۵

Eteone sp. Indet. Eteone californica

ASARCO STATIONS - RAW BIOLOGICAL DATA												
TAXON NAME	T8-4-A	T8-4-B	T8-4-C	T8-4-D	T8-4-E 	T8-4-TOT	T10-1-A	T10-1-B	T18-1-C	T10-1-D	T10-1-E	T10-1-TOT
Porifera sp. Indet.	3	1	1	0	9	5	1	4	1	i	. 6	7
Cnidaria sp. Indet.	8	8	9	8	9	9	9	8	, 0	8	9	. 0
Hydroida (encrusting) sp. Indet.	3	8	. 0	8	9	3	9	0	2	5	0	4
Obelia sp. Indet.	7	8	2	1	3	, 21	9	9	8	0	0	8
Sertulariidae sp. Indet.	1	10	8	1	4	16	0	8	8	9		8
Thuiaria sp. Indet.	8	0 .	9	9	8	9	9	0	8	0	0	. 0
Plumulariidae sp. Indet.	0	8	8	0	0	0	9	9	8	0	0	•
Anthozoa sp. Indet.	3	2	1	8	5	11	1	1	1	1	8	4
Pachycerianthus fimbriatus	0	0	0	0	0	, 0	8	0	8	8	8	•
Halcampa decemententaculata	1	0	2	•	0	3	9	0	. 0	9	. 9	0
Platyhelminthes	•	0	9	•	8	9	8	8	1	0	6	1
Polycladida sp. Indet.	1	0	9	8	8	1	8	9	9	0	. 0	8.
Kronborgia pugettensis	8	8	8	•	8	8	•	8	8	. 0	6	. 6
Turbellaria-Kalyptorhynchia sp. Indet.	•	0	0	0	1	1	. 0	0	9	8	9	9
Nemertea sp. Indet.	0	9	6	1	0	7	. 0	1	0	0	9	1
Tubulanus sp. Indet.	3	•	0	1	1	5	9	0	9	8	0	9
Cerebratulus sp. 1.		8	0	3	9	3	0		8	8	8	0
Lineus sp. Indet.	10	5	2	2	15	34	8	•	9	8	9	9
Micrura sp. Indet.	0	3	0	9	0	3	8	6	8	0	0	. 0
Nemertea-Enopla sp. Indet.	1	0	9	9	. 0	1	6	0	6	0	0	0
Amphiporus sp. Indet.	4	4	. 0	5	3	- 15	9	0	0	1	0	1
Nematoda sp. Indet.	1	2	9	1	9	13	9	1	6	8	0	1
Polynoidae sp. Indet.	6	ž	1	1	11	21	4	5	2	4	0	15
Halosydna brevisetosa	8	8	ē	ē		8	1	9	8	8	9	1
Harmothoe sp. Indet.	8	8	ě	9	0	9	9	9	0	0	0	8
Harmothoe imbricata	1	ē	ء و	Ā	1	6	ā		8	•	. 8	0
Harmothoe nr. H. lunulata	ā	ā		Ā	9	a	a		9	2	8	9
Lepidonotus squamatus	ğ	Ā	2	A	3	30	a	a	A	A	5	2
Lepidasthenia longicirrata	Ā	0	a		2	3	å	a	A	a	ā	9
Tenonia kitsapensis	•	a	<u> </u>	٠ ۵	_	<u> </u>	9	۵	A	a	a	a
Photoides asperá	14	43	19	14	29	146	2	ā	a	a	ā	2
Pholos minuta	4.	1	1	. 0	6	2	A	. 4	ā	. 1	1	2
Sthenelais berkeleyi		9	1	. 4	9	4	0	۵	·			- a
Sthemelais tertiaglabra	T D	<b>U</b>	0	Φ Δ	e e	D A	<b>0</b>	υ 0	۵	A	Δ	Q
Paleonotus bellis	•	•	υ Δ	4	<b>v</b>	•	15	£	27	Δ	1	57
	U A	<b>v</b>	•			<b>б</b>	7.2	D A	£/ 0		1	2
Phyllodocide sp. Indet.	Ø	V A	<b>U</b>	Ð	Ψ Δ	ď			<b>U</b>	O I		7
Phyllodoce sp. Indet.		•		v .	υ Δ	10 0	Ţ	9	ت 0	. 0	a a	. ,
Phyllodoce groenlandica	ال م	1 9	<b>V</b>	į	6 A	د .	V .	12	A A	. 6	11	39
Phyllodoce mucosa		<b>U</b>	4		. V	' <b>'</b>	. D	. 6	4	D A	6	23
Eteone sp. Indet.	¥	ď	1	1	8	1.5		_	ď	В Д	. 4	2
Eteone californica	U	8	0	V	9	. 0	4	5	•			ь
			,•	;	**					1		
				i						,		
•												

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-E	T11-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-TOT
Porifera sp. Indet.	0	0		ė	8		0	9	0	8	8	6
Cnidaria sp. Indet. Hydroida (encrusting) sp. Indet.	9 8	0 1	9	9	0 0	<b>0</b> 1	0 8	<b>8</b>	· 0	9	9	8
Obelia sp. Indet. Sertulariidae sp. Indet.	<b>9</b> 1	0	5 8	<b>6</b> 1	0 1	<b>0</b> 5	<b>0</b>	<b>6</b> 5	5 0	1 8	8	8 0
Thuiaria sp. Indet. Plumulariidae sp. Indet.	3 0	<b>8</b>	1 8	<b>6</b> 5	. 1	9 8	0 8	<b>0</b> 8	8	1 8	9	1 8
Anthozoa sp. Indet. Pachycerianthus fimbriatus	8 6	0	9 8	é	0 0	. 0	<b>8</b>	0 8	8	9	<b>0</b>	9 9
Halcampa decemententaculata Platyhelminthes	8	<b>e</b> 8	8	9	8	. 8	8	• 0	0 8	0 8	8	• 0 8
Polycladida sp. Indet. Kronborgia pugettensis	. 8	8	9	8	9	9	0 8	<b>e</b> 9	<b>0</b>	0 6	<b>0</b> 6	<b>8</b> 8
Turbellaria-Kalyptorhynchia sp. Indet. Nemertea sp. Indet.	8	<b>0</b> 1	<b>8</b> 1	8	1	1 4	0	8	8	<b>6</b> 2	0	0
Tubulanus sp. Indet. Cerebratulus sp. 1.	9	<b>9</b>	8	9	8	0	9	9	<b>0</b>	e e	9 8	8
Lineus sp. Indet. Micrura sp. Indet.	9	8	9	8	8	0	0	9	0	8	9	0
Nemertea-Enopla sp. Indet.		0	8	9	9	9	8	9	8	9	0	8
Amphiporus sp. Indet. Nematoda sp. Indet.	9	9	0	8	9	0	8	8	8	8	9	. 0
Polynoidae sp. Indet. Halosydna brevisetosa	8	9	9	8	8	8	0	0	6	8	1	0
Harmothoe sp. Indet. Harmothoe imbricata	9	0	9	. 0	8	0 1	8	<b>8</b> B	0	8	8	8
Harmothoe nr. H. lunulata Lepidonotus squamatus	<b>0</b>	<b>9</b>	0 8	8	<b>8</b>	0	9	<b>9</b>	<b>8</b> 8	0	<b>8</b>	<b>8</b> 0
Lepidasthenia longicirrata Tenonia kitsapensis	<b>8</b> 8	0 8	9 8	9	8	0 8	8	9 8	0 8	0 0	8	8
Pholoides aspera Pholoe minuta	9 8	5 A	8 8	<b>8</b>	0	5 9	9	0	8	1	9	1 2
Sthenelais berkeleyi Sthenelais tertiaglabra	9	0	9	9	. 0	0	8	8	9	9	8	8
Paleonotus bellis	9	8	9	9	8	9	6	9	8	5 a	8 2	11
Phyllodocide sp. Indet. Phyllodoce sp. Indet.	8	8	8	8	0 0 ·	8	8	3	8	5	e 8	8
Phyllodoce groenlandica Phyllodoce mucosa	0	0	8	8	8	8	i	8	1	9	9	11 2
Eteone sp. Indet. Eteone californica	8	8	8	9	8	9	. 9	9	. 8	1	1	5

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T16-1-A	T16-1-B	716-1 <i>-</i> C	T16-1-D	716-1 <i>-</i> €	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	T16-4-D	T16-4-E	T16-4-TOT
4 - 1		Α		Α				_				•
Porifera sp. Indet.	<b>8</b>	9		<b>V</b>	9	<b>8</b>	<b>8</b>		Ø A	9	9	
Cnidaria sp. Indet.	0 0	9	4	# A	<b>0</b>	4	• • • • • • • • • • • • • • • • • • •	4	4		•	<b>6</b>
Hydroida (encrusting) sp. Indet. Obelia sp. Indet.	A	۵	2	0 0	<b>A</b>	· 0	Δ	٠	A	Δ	9	a
Sertulariidae sp. Indet.	A	a	a	a	1	1	1	4	1	8	2	Ă
Thuiaria sp. Indet.	6	ă	2	1	5	14		Ä	Å	ā	a	Ä
Plumulariidae sp. Indet.	6	9	3		9	9	a	a	á	9	8	ě
Anthozoa sp. Indet.		8	0	ě	9		9	ě	8		9	ē
Pachycerianthus fimbriatus	8	8	0	0	0	9	9	9	0	9	0	0
Halcampa decemententaculata	0	9	8	0	0	8	1	0		9	0	1
Platyhelminthes	8		0	8	8	0	8	9	0	8	9	8
Polycladida sp. Indet.	8	8	9	8	8	8	8	0		<b>e</b> '	9	0
Kronborgia pugettensis	8	0	8 .	. 8	9	0	0	0		0	8	0
Turbellaria-Kalyptorhynchia sp. Indet.	9	9	9	8	9	è	0	9	8	9	8	Ò
Nemertea sp. Indet.	0	8	8	0	0	9	0		0	0	9	9
Tubulanus sp. Indet.	0	0	9	8	0	0	9	0	8	8	8	0
Cerebratulus sp. 1.	9	8	0	8	Ó	9	8	0	8	0	0	0
Lineus sp. Indet.	1	1	1	3	7	13	0	8	0	9	0	. 0
Micrura sp. Indet.	11	18	13	12	14	68	8	8	8	8	8	8
Nemertea-Enopla sp. Indet.	0	0	2	8		2	0	8	9	9	8	8
Amphiporus sp. Indet.	8	0	8	8		8		8	0	0	0	
Nematoda sp. Indet.	9	0	0	8	8	. 8	. 0	0	1	1	0	2
Polynoidae sp. Indet.	1	1	1	•	1	4	8	8	8	9	0	8
Halosydna brevisetosa	0	6	9	9	6	0	8	0	9	9	8	8
Harmothoe sp. Indet.	0	8	9	0	9	0	8	8	8	0	0	0
Harmothoe imbricata '	0	9	8	0	0	0	9		0	9	9	9
Harmothoe nr. H. lunulata	8	0	0	8	ė	0	1		8	8	0	1
Lepidonotus squamatus	8	0	0	0	3	3	0	0,	9	8	8	0
Lepidasthenia longicirrata	0	9	9	9	9	0	8	8	9	0	0	8
Tenonia kitsapensis	8	0	8	8	9	8	9	0	8		0	0
Pholoides aspera	8	8	•	, 3	6	9	, i 6	ı <b>1</b>	11 8			$v_{ij} = v_{ij} = v_{ij} 1_{ij} v_{ij}$
Pholoe minuta	1	6	0	0	1	8	1	1		8	0	5
Sthenelais berkeleyi	0	8	8	1	0	1	0	i	0	8	1	2
Sthenelais tertiaglabra	8	8	0	0	0	9	0	1 8	0	. 8	. 8	0 -
Paleonotus bellis	0	0	0	0	8	0	v	9	•	. 8	9	0
Phyllodocide sp. Indet.	8		8	8			· •		8	8	8	<b>6</b> ·
Phyllodoce sp. Indet.	0	1	1	8	. 0	2.	i 0	1	9	• •	6	1 P
Phyllodoce groenlandica	1	9	8	9.	1	5	. 9	r 🐧	5	· 8	•	5 ,
Phyllodoce mucosa	0	1	8	8	0	1	0	. 0	0	0	0	0
Eteone sp. Indet.	0	8	8	0	0	0	8	0	8	8	0	8
Eteone californica	3	1	0	8	0	<b>.</b>	. 0	1 8	•	1	. 0	1

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ASARCO STATIONS - RAN BIOLOGICAL DATA TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-TOT	T22-2-A	T22-2-B	7-S-51	T22-2-D	T22-2-E	T22-2-TOT	1 1 	Grand Total
Porifera sp. Indet.	9	5	9	. 0		2	8	8		9	8	. 0	ı	37
Cnidaria sp. Indet.	8	8	0		8	8	0	0	8	. 8	0	9	J	2
Hydroida (encrusting) sp. Indet.	8		9		0	0	9	0	0	0	0	0	1	8
Obelia sp. Indet.	8	8	8	8	8	9	0	8	8	0	8		- 1	33
Sertulariidae sp. Indet.	9	1	9	U	9	1	0	9	8	0	8	8	•	36
Thuiaria sp. Indet.	47	9			Ø.	9	1	1	2	. 2	3	9	!	38
Plumulariidae sp. Indet.	17	U	9	V	8	25	9		9	0	8	0	1	92
Anthozoa sp. Indet.	9	U			v	Ø	8	0	1	9	8	1	1	28
Pachycerianthus fimbriatus	8	9	9	¥	9	0	0	8		9	0	0	ı	9
Halcampa decemententaculata	8		9	8	0	0	0	1	1	0	8	5	ļ	11
Platyhelminthes	8	0	8		8	8	8	. 0	8	8	0	0	ı	5
Polycladida sp. Indet.	9		0	0	8	0	0	8	0	0	0	8	ı	2
Kronborgia pugettensis	0	0	0	8	0	0	0	9	9	0	8	8	1	38
Turbellaria-Kalyptorhynchia sp. Indet.	1	8	0	8	8	1	0	0	9		8	8	ı	4
Nemertea sp. Indet.	4	2	3	0		9	5	2	3	6	1	8	ı	48
Tubulanus sp. Indet.	0	0	8	8	0	8	0	0	. 0	0	0	0	ı	B
Cerebratulus sp. 1.	9	0	0	8		8	40	23	18	12	36	129		140
Lineus sp. Indet.	8	9	0	0	0	0	3	1	5	. 0	8	9	ļ	63
Micrura sp. Indet.	8	8	. 0	2	0	2	0	8	0	0	0	8	ı	71
Nemertea-Enopla sp. Indet.	0	8	0	8	0	0	8	0	8	. 0	9	9	i	5
Amphiporus sp. Indet.	3	14	11	5	2	35	0	0	0	0	8	0	ı	55
Nematoda sp. Indet.	8	5	4	2	6	25	2	0	8	0	8	2	-	44
Polynoidae sp. Indet.	4	5	1	1	7	15	1	3	4	· 9	1	50	ı	278
Halosydna brevisetosa	8	8	9	8	8	8	9	8	8	8	0	0	-1	2
Harmothoe sp. Indet.	8	8	9	8	ê	0	0	8	0	8	0	0	i	2
Harmothoe imbricata	0	8	0	0	0	8	2	3	8	0	0	5	1	14
Harmothom nr. H. lunulata	1	5	9	0	1	7	8	ė	0	8	8	0	1	8
Lepidonotus squamatus	8	- <b>0</b>	9	0	8	8	0	0	8	8	0	8	1	81
Lepidasthenia longicirrata	9	0	9	8	8	0	0	8	9	8	8	0	i	9
Tenonia kitsapensis	1	0	1	8	1	3	0	8	8	8	8	8	1	3
Pholoides aspera	7	0	9	2	5	14	39	42	26	24	. 12	143	-	1639
Pholoe minuta	1	1	5	1	1	9	1	2	1	1	2	7	1	48
Sthenelais berkeleyi	9	8	0	0	5	2	1	8		8	0	. 1	1	7
Sthenelais tertiaglabra	0	0	0	8	8	8	0	0	0	8	0	0	1	1
Paleonotus bellis	2	8	2	8	5	6	0	2	1	8	1	4	ı	78
Phyllodocide sp. Indet.	8	0	0	1	0	1	0	0	8	2	0	2	ŀ	16
Phyllodoce sp. Indet.	1	4	8	8	3	8	8	0	0	8	0	0	ı	27
Phyllodoce groenlandica	0	0	0	8	0	0	8	0	0	٠ 8	0	9	1	12
Phyllodoce mucosa	8	1	0	0	1	2	1	1	8	0	3	5	ł	74
Eteone sp. Indet.	8	0	6	8	0	9	8	0	0		8	0	1	2 .
Eteone californica	1	2	11	8	1	23	2	1	0	2	9	5	ł	48

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-€	T2-5-TO <b>T</b>	T3-5-A	T3-5-9	13-5-C	T3-5-D	13-5-E	T3-5-T0T
Eteone longa	9		6	0		•	0	9	0	0	0	8
Eulalia viridis	0	0	9	8		9	0	ė	0	8	. 0	6
Eulalia bilineata	9	0	9	0		0	0	8	0	9	8	8
Eulalia levicornuta		9	8	0	ŧ	8	0	8	8	0	0	8
Paranaitis polynoides	0	8	0	0		<b>8</b> :	8	8	0	0	0	0
Eumida sanguinea	0	1	0	8		1	1	0	3	6	4	14
Phyllodoce hartmanae	0	0	0	1		1	9	0	0	i	8	1
Glyceridae sp. Indet.	8	9	9	8		0	0	8	8	0	8	0
Hesionidae sp. Indet.	9	0	9	0		0	0	. 0	0	8	0	0
Hesionidae sp. 1	9	8	9	0		0	0	8	9	9	9	0
Microphthalmus sp. 1	9	0	8	0		0	0	8	0	•	8	` @
Gyptis brevipalpa	0	0	0	•		8	0	8	8	0	9	8
Ophiodromus pugettensis	0	8	0	0		0	8	8	8	8	0	•
Kefersteinia cirrata	8	0	0	0		0	0	8	9	0	8	6
Micropodarke dubia	8	1	1	0		2	8	0	8	9	4	4
Sigambra tentaculata	0	8	0	8		0	8	•	0	9	8	8
Pilargis berkeleyae	1	8	9	0		1	0	0	8	0	9	6
Syllidae sp. Indet.	8	0	8	9		0	8	0	0	9	1	1
Autolytus sp. Indet.	8	0	0	0		0	9	8	8	0	9	6
Syllis gracilis	0	0	0	0		9	8	. 8	0	8	8	6
Syllis elongata	9	9	9	9		9	0	0	8	9	8	
Eusyllis assimilis	0	0	0	0		0	1	5	ē	0	9	
Exogone lourei		0	á	9		8		9	8	9	8	
Sphaerosyllis brandhorsti	8	8	9	. 0			Ä	9	A	9	9	
Syllis heterochaeta	ā	A	a	Ā		Ä	ĭ	A	Ā	ā	3	
Odontosyllis phosphorea	7	4	4	å		15		1		23	7	31
Nereis sp. Juv	, 2	Å	,	1			A		. a	A	A	
Nereis procera	- A	1	å	á	•	i	å	ā	1	ĭ	ā	,
Nereis wailesi	a	a	a	9		å	<u> </u>	a	å	a	ā	2
Platynereis bicanaliculata		0	ā	•		9	<b>A</b>		<u> </u>	Ā	Ā	ì
Nephtys sp. Indet.	Ä	<u>a</u>	<u>a</u>	a			4				a	
Nephtys caeca		<u> </u>	•	•	•		Δ	•	•	<b>a</b>		
Nephtys cornuta franciscanum	ā	4	a	<u>a</u>		å	a		4	a	•	4
Nephtys ferruginea	Á	4	5	, <del>U</del>		14	2	4	4	5	4	11
Sphaerodoropsis sphaerulifer	7	7	<u>ε</u>	7		9	<u> </u>	4	•	a	7 A	
Glycera sp. Indet.	•	υ Δ	v A	0		0	0	<b>V</b>	2	υ Δ	<b>u</b>	9
Glycera sp. Indet. Glycera capitata	1	5	<b>U</b>	4			, A	υ Δ	9	. 4	•	•
	ı	e 0	Д	1		4 1. A	· 6	, D	•		ı	1
Glycera americana	•	_	. 0	, 0	:	<b>U</b>	· •	'. U	0	• •	<b>U</b>	•
Goniadidae sp. Juv	0	8	V	v		. 6		9	<b>U</b>	•	ď	¥
Blycinde picta	9	0	U				0		V		ı <b>U</b>	
Glycinde armigera	0	Ø	8	0		. 0	0	6	6	1	8	,

asarco stations – Raw Biological Data Taxon Name	A-2-4T	T4-2-B	T4-2-C	T4-2-D	74-2-E	T4-2-TOT	T6-3-A	T6-3-B	16-3-C	T6-3-D	76-3-E	T6-3-T0T
Eteone longa	9	. 0	8	9	0	0		0	8	0	8	
Eulalia viridis	0	9	0	8	8		9	8	8	0	9	ē
Eulalia bilineata	. 2	5	4	À	5	17	3	3	2	3	0	11
Eulalia levicornuta	i <b>1</b>	1	2	9	1	5	8	8	1	<u> </u>	0	2
Paranaitis polynoides	0	8	0	8	0	0	8	•	8	a	8	
Eumida sanguinea	4	4	24	29	3	64	15	22	7	41	4	89
Phyllodoce hartmanae	8	0	9	1	` <b>e</b>	1	8		Ġ	8		a
Glyceridae sp. Indet.	0	e	0	ě	1	1	2	4	4	3	1	14
Hesionidae sp. Indet.	9	0	ē	9	ā	ā		á	à	A		. · ·
Hesionidae sp. 1	ā	2		e		9	A	Ä	Ä	A	A	a
Microphthalmus sp. 1	ā	9		ě	Ä	a	Ä	Ā	ā	a	a	a
Byptis brevipalpa	ē	ā	Ā	ā	ā	a	Ā	å	Ā	Ā	<u> </u>	<u> </u>
Ophiodromus pugettensis	ě	8		8	ě	ă	9	ä	â	å	ā	a
Kefersteinia cirrata	ā	3	A	. a	8	11	Ä	Ā	1	A	A	1
Micropodarke dubia	8	ē	8	Ã	Ā	Ä	Ā	Ä	•	ě	å	•
Sigambra tentaculata		ě	2	ě	A	Ã	Ä	Ä	Δ	Ď	ā	<u> </u>
Pilargis berkeleyae	ē	ě	ā	a	A	Ä	a	Δ		4	۵	4
Syllidae sp. Indet.		8	3	2	A	5	ă	•	· A	<b>a</b>	Ā	4
Autolytus sp. Indet.	ā	9	8	8	A	9	A	, A	1	<u> </u>		1
Syllis gracilis	Ā	ā	Ā	ā	۵	ă	۵	. 0	2	Δ	Δ.	
Syllis elongata	A	a	Ä	a	۵	ă	<u>۵</u>	Δ		Δ	4	9
Eusyllis assimilis	22	130	- 69	4	2	223	2			2		0
Exogone lourei	4	130	2	4	ε Δ	EE3	<u> </u>	۵. ت		E 0	4	0
Sphaerosyllis brandhorsti	•	4	Δ	٠ ٥		9	<b>0</b>		0	7		9
Syllis heterochaeta		a	٠. ۵	<u> </u>	φ Δ	<u> </u>	Δ	0	.0	3	4	3
Odontosyllis phosphorea		a	7	9		32	0	0	7	17	9	44
Nereis sp. Juv	D A	D A	4	9	2	32	7	7	/	17	2	44
Hereis procera	<b>5</b>	D.	4	D A	•	•	0	0	6	1		1
Vereis wailesi	7	Δ	4	7		7	•	0	•	•		
Platymereis bicanaliculata	3		0	•		•	•				1	1
Mephtys sp. Indet.		1	<b>0</b>	<b>u</b>	9	1		0	8			9
Rephtys caeca	4	9	D A	4	. 0	•	0				Ţ	1
Mephtys cornuta franciscanum	•	0 A	<b>D</b>	0	<b>.</b>		•	2	£	0	<b>8</b>	9
Vephtys ferruginea	<b>v</b>	D Δ	D A	Δ	0	Ø A	<b>U</b>	<b>6</b>		<b>U</b>	<b>U</b>	0
Sphaerodoropsis sphaerulifer	<b>U</b>	8	υ Δ	<b>U</b>	4	<b>U</b>	ے م	3	5	13	3	27
Glycera sp. Indet.	<b>U</b>	9	υ Δ	D h	<b>8</b>	<b>U</b>		<b>6</b>	•	0	8	8
Glycera sp. Indet. Glycera capitata	17	18	17	10	0	6	9	y	6			0
Slycera capitata Slycera americana	13	9	1/ a	10	10	68	8	4	. 4	5	j	22
Soniadidae sp. Juv	<b>0</b>	9	σ <u>α</u>	0 0	0	9	8	<b>0</b>	<b>U</b>	V		9
Blycinde picta	. 8		υ Δ	-	-	V	_	ð	9	V	Ű	0
Slycinde armigera		8	•	<b>6</b> 3	8	Ø	. 1	e Q	W	8	8	9

ASARCO STATIONS - RAW BIOLOGICAL DA TAXON NAME	T8-4-A	T8-4-B	T8-4-C	T8-4-D	T8-4-€	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
Eteone longa	2	0	0	0	0	2	8	6	. 0	<b>G</b> '		
Eulalia viridis		8	0	8	0		0	0		8	9	0
Eulalia bilineata	3	5	3	1	2	14	0	0	0	8	0	9
Eulalia levicornuta	8	0	8	9	0	8	9	1	0	2	0	3
Paranaitis polynoides	0	0	9	0	9	6	8	0	0	0	0	0
Eumida sanguinea	6	12	16	8	8	50	4	8	5	5	7	26
Phyllodoce hartmanae	8	1	8	8	1	2	8	0	8	8	0	8
Glyceridae sp. Indet.	8	0	9	9	0	9	0	3	1	i	8	5
Hesionidae sp. Indet.	0	0	9	9	0	8	8	8	8	8	8	0
Hesionidae sp. 1	8	0	8	0	9	9	0	8	8	8	0	9
Microphthalmus sp. 1	8	0	8	8	8	8	8	8	0	8	8	0
Gyptis brevipalpa	. 8	8	8	0	9	9	8	0	8	8	0	0
Ophiodromus pugettensis	1	0	0	1	9	2	. 0	•	8	8	8	9
Kefersteinia cirrata	•	9	0	0	•	•	12	13	16	17-	6	64
Micropodarke dubia	6	0	0	•	0	0	0	. 0	0	8	9	0
Sigambra tentaculata	8	0	0	8	8	9	8	8	i <b>6</b>	0	9	0
Pilargis berkeleyae	0	8	9	0	0	0	0	, 8	6	8	0	0
Syllidae sp. Indet.	9	0	0	0	1	1	8	<b>' 0</b>	8	1	8	1
Autolytus sp. Indet.	0	0	0	0	8	0	0	0	8	0	8	8
Syllis gracilis	9	9	8	8	8	0	1	1	0	2	8	4
Syllis elongata	8	0	8	8	0	0	8	9	8	0	.0	9
Eusyllis assimilis	0	0	0	0	8	0	8	8	8	1	1	2
Exogone lourei	0	0	0	8	6	. 8	8	0	8	8	0	0
Sphaerosyllis brandhorsti	0	0	9	0	9	0	0	8	8	8	0	9
Syllis heterochaeta	6	0	9	8	8	8	8	8	0	0	. 0	9
Odontosyllis phosphorea	. 6	4	11	10	5	36	1	6	1	8	0	8
Nereis sp. Juv	8	8	9	1	9	i	8	8	8	8	8	0
Nereis procera	9	9	8	8	•	0	8	8	8	8	0	8
Nereis wailesi	. 0	8	0	9	0	0	8	•	8	8	8	0
Platynereis bicanaliculata	. 6	0	0	8	1	1	1	4	3	. 6	1	15
Nephtys sp. Indet.	. 0	0	0	0	0	8	1	8	8	0	9	1
Nephtys caeca		0	0	3	9	3	. 1	5	, 0	0	0	1 3
Nephtys cornuta franciscanum	8	8	0	0	8	8	8	8	. 6	8	0	. 8
Nephtys ferruginea	3	7	11	12 .	10	43	8	1	2	0	5	5
Sphaerodoropsis sphaerulifer	0	8	0	0	8	9	0	0		0	8	9
Glycera sp. Indet.	9	0	8	9	0	9	. 0	9	8	9	9	9
Glycera capitata	1	2	1	2	0	6	8 :	12	7 .	1	4	35
Glycera americana	9	9	. 0	8 .	Ģ	0	0	8	0	9	9	9
Goniadidae sp. Juy	6	0	8	8	0	0	0	0	9	8	8	9
Olycinde picta	8	9	8	8	9	9	. 8	. 0	8	0	9	9
Glycinde armigera	ē	1		1 :	1	5		a	9	9	. 0	0

ASARCO STATIONS - RAW BIOLOGICAL DATA	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-F	T11-7-T0T	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-F	T12-1-T01
itioms same			·	··								
Eteore longa	. 0	0	0	. 8	0	0	8	8	e	0		(
Eulalia viridis	8	8	0	0	. 9	0	1	8	8	8	8	1
Eulalia bilineata	6	6	8	0	8	8	8	8	0	8	0	•
Eulalia levicornuta	8	9	9	9	0	8	0	0	0	8	8	(
Paranaitis polynoides	0	1	1	9	0	2	8	0	8	0	8	(
Eumida sanguinea	8	6	1	0	. 8	7	2	1	. 0	4	5	į
Phyllodoce hartmanae	1	8	8	8	0	1	0	, <b>0</b>	. 8	0	8	(
Glyceridae sp. Indet.	0	8	8	9	8	9	9	0	9	0	9	(
Hesionidae sp. Indet.	0	9	0	0	0	8	9	8	8	8	8	•
Hesionidae sp. 1	8	0	8	8	8	8	0	8	0	0	8	
Microphthalmus sp. 1	. 8	0	8	0	0	0	9	8	8	8	6	(
Gyptis brevipalpa	. 8	8	8	0	8	8	9	0	• 8	9	0	(
Ophiodromus pugettensis	8	8	. 8	0	8	. 8	0	8	0	8	0	(
Kefersteinia cirrata	8	0	0	0	8	8	3	8	8	-1	1	
Micropodarke dubia	8	0	8	0	0	8	0	8	8	0	8	•
Sigambra tentaculata	8	0	0	8	0	0	0	0	8	8	0	(
Pilargis berkeleyae	8	0 .	0	8	0	0	0	9	8	0	8	(
Syllidae sp. Indet.	8	5	8	9	9	5	8	1	8	1	9	í
Autolytus sp. Indet.	0	ß	ø	0	0	8	0	8	0	0	0	(
Syllis gracilis	0	9	8	9	8	0	1	0	8	. 0	0	1
Syllis elongata	0	1	0	8	8	1	Ģ	8	0	8	6	•
Eusyllis assimilis	0	Ģ	0	9	0	0	9	8	į <b>8</b>	0	9	•
Exogone lourei	0	. 0	Ó	0	0	0	0	. 6	8	8	0	(
Sphaerosyllis brandhorsti	0	9	9	9	8	8	9	8	0	8	0	•
Syllis heterochaeta	8	1	8	9	8	.1	0	8	8	0	0	(
Odontosyllis phosphorea	0	5 ·	8	0	1	3	1	8	0	5	8	3
Nereis sp. Juv	0	0	8	0	- 0	8	8	8	8	6	0	•
Nereis procera	8	8	8	9	8	8	8	8	8	8	8	(
Nereis wailesi	9	8	0	9	0	0	0	8	8	8	0	(
Platynereis bicanaliculata	•	0	0	0	0	8	4	1	9	0	0	;
Nephtys sp. Indet.	0	0	8	ø	0	0	0	8	0	8	0	(
Nephtys caeca	0	8	0	0	0	0	2	0	8	1	9	
Nephtys cornuta franciscanum	8	0	. 6	0	0	0	0	0	0	8	0	•
Nephtys ferruginea	6	7	13	5	5	33	3	Ģ	0	1	0	4
Sphaerodoropsis sphaerulifer	8	8	0	. 0	8	0	0	8	0	8	8	(
Glycera sp. Indet.	0	0	8	9	0	9	9	0	8	0	8	•
Glycera capitata	1	0	. 1	0	0	2	0	1	2	3	0	
Glycera americana	<b>@</b> .	8	8	0	0	8	0	8	8	8	8	(
Goniadidae sp. Juv	0	Ø	0	0	0	0	0	8	0	. 0	0	(
Glycinde picta	8	0		0	0	0	2	8	0	0	0	í
Glycinde armigera	0	0 .	0	9	0	0	0	9	0	0	8	

. .

TAXON NAME	T16-1-A	T16-1-8	T16-1-C	T16-1-D	₹16-1-E	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	716-4-D	T16-4-€	T16-4-TOT
Eteone longa	0	0	8	9	0	0	0	0	0	0	0	0
Eulalia viridis	8	8	8	8	8	9		8	6	8	8	. 0
Eulalia bilineata	0		•	8	0	8	•	9	9	8	9	0
Eulalia levicornuta	8	9	9	8	6	9	9	9	9	0	9	0
Paranaitis polynoides	0	0	0	8	9	0	0	. 0	8	0	0	9
Eumida sanguinea	. 6	5	8	3	7	29	i	• 8	9	8	8	1
Phyllodoce hartmanae	0	0	0	4	2	6	0	1	1	8	9	2
Glyceridae sp. Indet.	6	0	0	9	0	0	9	9	0	9	8	0
Hesionidae sp. Indet.	8	0	0	9	•	0	0	0	8	•	0	0
Hesionidae sp. 1	2	9	0	0	9	2	9	8	8	9	0	0
Microphthalmus sp. 1	0	9	0	6		0	0	8	8	9	8	9
Gyptis brevipalpa	8	9	8	. 6	0	9	8	8	9	9	0	0
Ophiodromus pugettensis	1	0	8	0	0	1	8	8	8	0	0	0
Kefersteinia cirrata	9		8	9	6	6	9	8	8	9	8	8
Micropodarke dubia	. 0	0	8	8	0	8	8	0	9	0	8	8
Sigambra tentaculata	1	8	0	0	. 0	1	0	8	8	9		0
Pilargis berkeleyae	8	0	8	0	9	9	9	•	8	0	0	0
Syllidae sp. Indet.	9	0	0	8	9		0		•	8	0	0
Autolytus sp. Indet.	0	0	8	8	0	0	8	8	•	0	8	8
Syllis gracilis	9	0	0	0	9	. 0	0	0	•	9	0	
Syllis elongata	13	3	3	8	5	24	0	0		8	9	0
Eusyllis assimilis	9	9	0	8	0				0	9	0	. 0
Exogone lourei	9	4	10	8	11	42	8	0	9	0	0	0
Sphaerosyllis brandhorsti	9	9	9	8	8	. 0	9	8		8	8	0
Syllis heterochaeta	1	8	i	8	1	3	8	8	2	9	8	2
Odontosyllis phosphorea	0	0	8	0		. 0	8	0	8		9	9
Nereis sp. Juv	. 0	9	9	8		. 0			9	8	8	8
Nereis procera	9	8	9		g	. 8	9	9	8	. 8	9	6
Nereis wailesi	0	0	0	0	•	9	0	0	8	8	0	9
Platymereis bicamaliculata	8	0	9	8	1	1	9	8			0	8
Nephtys sp. Indet.	1	. 0	0	9		1	8	0	8	. 0	0	. 0
Nephtys caeca		1	1			2	9			. 8	9	8
Nephtys cornuta franciscanum	5	5	7	1	16	28	2	1	8	4	0	7
Nephtys ferruginea	29	21	38	24	29		2	4	15	12	12	42
Sphaerodoropsis sphaerulifer	A	9	A	A	2		a	Å	8	0	9	. 0
Glycera sp. Indet.	Ä	A	a	A	g	. A	A	A	a	8	8	. 2
Glycera capitata	A	3	12	<u> </u>		31	1	3	1	ء ۽	2	9
Glycera americana	٥	9	, L	A	ě		ā	9	â	Ā	A	A
Goniadidae sp. Juv	a	9	Δ	4		, 0	<u> </u>	۵	Ω	A	9	
Glycinde picta	<b>U</b>	A	. 0	Δ		, 0	Δ	۵	۵	9	Δ	Ω
Glycinde armigera	2	4	2	3		12	A	8	0.	9.	a	

ASARCO STATIONS - RAN BIOLOGICAL													J
TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-TOT	T22-2-A	T22-2-B	T22-2-C	T22-2-D	T22-2-E	T22-2-TOT	l 
Thomas Name	a		•	Q	۵		a	a	a	Δ	ı <b>0</b>	a	9
Eteone longa Eulalia viridis	9	0	8	9	0	9	8	0	8	0	9	8	}
Eulalia bilineata Eulalia levicornuta	2 8	<b>9</b> 12	9	9	2 11	6 31	4	4	4	4	. 4	20 2	l l
Paramaitis polymoides	. <b>0</b> 32	0 19	0 13	9	9	<b>9</b> 83	8	0	9	9	. e 5	<b>9</b> 16	1
Eumida sanguinea Phyllodoce hartmanae	5	6	4	4	11	39	9	9	8	0	. 0	0	<b>.</b>   .
Glyceridae sp. Indet. Hesionidae sp. Indet.	<b>0</b> 7	9 9	9	1 0	2 6	, <b>55</b>	0 0	9 a	9 2	. <b>8</b>	. 8	8	i I
Hesionidae sp. 1	8	8	9	ě	0	0	0	0	0	6	0	8	!
Microphthalmus sp. 1 Gyptis brevipalpa	<b>9</b> 8	2 6	2	1	1 8	3 25	8	2	3	9	1	<b>0</b> 6	! !
Ophiodromus pugettensis Kefersteinia cirrata	1 45	<b>8</b> 32	5 17	5 16	6 16	17 127	0 13	0	<b>0</b> 15	9	3 17	3 . 58	) 1
Micropodarke dubia	. 0	8	0	6	9	9	0	9	8		0	8	!
Sigambra tentaculata Pilargis berkeleyae	1 1	<b>9</b> 1	. 2	<b>.</b>	9	1 2	1 0	0 0	4 2	1	3	9	 
Syllidae sp. Indet.	0	•	9	1	0	ī	0	0	2	0	1	3	
Autolytus sp. Indet. Syllis gracilis	0	0	1	9	9	3	0	. 8	0	0	. 8	<b>9</b>	l i
Syllis elongata Eusyllis assimilis	18	0	6	6	1	23 3	0	0	1	0	e e	1 .	] i
Exogone lourei	48	25	66	28	58	217	19	23	33	11	14	199	I
Sphaerosyllis brandhorsti Syllis heterochaeta	11 17	0 35	5 10	2 5	1 3	19 70	8	<b>0</b> 3	9	8	<b>8</b> 15	<b>9</b> 1	( 
Odontosyllis phosphorea	8			. 0	1	1	0	8	1	8	0	i .	İ
Nereis sp. Juv Nereis procera	7	. 4	1	5	7	24	0	8	9	9	9	9	i
Nereis wailesi Platymereis bicanaliculata	. 20	0 11	9 14	1	<b>0</b>	1 52	6 a	3 a	13	4	7	33 0	<b>i</b> I
Nephtys sp. Indet.	4	9	1	8	9	5	3	0	9	4	3	10	i
Nephtys caeca Nephtys cornuta franciscanum	5 0	8	0	8	1	1 6	1	8	9	9 1	<b>0</b>	1 i	\$ 
Nephtys ferruginea	12	7	2	2 8	3	26	8	0	1	0	8	1	ł
Sphaerodoropsis sphaerulifer Glycera sp. Indet.	8	0	. 0	8	8	8	9	9	8	<b>0</b>	8	1   0	l
Glycera capitata Glycera americana	8	7	8 0	14 0	15 0	52 3	11 0	12 0	10 1	5 6	12 0	50   1	
Goniadidae sp. Juv	5	0	9	8	8	5	0	9	0	8	9	8	ı
Glycinde picta Glycinde armigera	9	0 3	5	<b>0</b> 3	1	1 16	8	0	<b>8</b>	<b>e</b> 1	0	<b>9</b>   5	

TAIDN NOME	ASARCO STATIONS - RAW BIOLOGICAL DATA					1							
Druphis   Drup		T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-E	T2-5-TOT	T3-5-A	T3-5-B	13-5-C	T3-5-D	T3-5-€	T3-5-TOT
Drumphis p. Jav.	Goniada brunnea	8	í	8	•		1	2	0	. 3	2	8	7
Doughis iridescens	Onuphidae sp. Juv	0	•	9	9		. 0	8	8	8	9	9	ė
Disciption elegans	Onuphis sp. Juv.	0	0	0	9			. 8	8	8	0	0	ē
Dilopatra cornata		8	0	9	9		0		6	0	6		
Lumbrimeris sp. Indet.	Onuphis elegans	0	0	8	8		9	8	0	8	9	8	9
Lumbrimeris sp. Indet.	Diopatra ornata	В	7	3	+ 1		19	5	10	17	13	12	57
Lumbrimeris californiemsis	Lumbrineris sp. Indet.	8	0	0	0		8	8	0	8		8	. 3
Notocirrus californiensis		8	0	9	8		8	, 0	ė		0	8	0
Dorvilled sp. Indet.	Lumbrineris californiensis	8	0	8	8		8		8	0	8	0	0
Doville pseudorutrovittata	Notocirrus californiensis	9	9	9	8		0	. 0	8	8	. 0	8	8
Dorvillea japonica		9	8	8	0	·	0	. 0	0		. 8	0	9
Protodorvillea pracilis	Dorvillea pseudorubrovittata	8	9	8	9	ı	0		8	8	0	0	
Dorvillea rudolphi	Dorvillea japonica	0	0	0	0		0	9	8	.0	8	0	. 0
Dorvillea caeca	Protodorvillea gracilis	8	8	8	9		8	0	8	8	9	0	0
Laonice pugettensis	Dorvillea rudolphi	9	8	1	0		i	8	8	1	0	1	2
Leitoscoloplos pugettensis  8	Dorvillea caeca	9	9	9	8			9		8	0	9	9
Naineris uncinata 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Laonice pugettensis	1	9	8	9		1	8	0	8	1	9	1
Scolopios acmeceps	Leitoscoloplos pugettensis	8	0	9	8		8	0	8	0	8	0	8
Paraonidae sp. Indet.  8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Naineris uncinata	0	0	8	8		8	8	0	8	0	0	8
Aricidea mr. A. suecica  B. 1 B. B. 1 B. B. 1 B. B. B. B. B. B. B. B. B. B. B. B. B.	Scolopios acmeceps	0	8	. 0				9		0	0	9	0
Levensenia gracilis	Paraonidae sp. Indet.	9	8	0	8		8	0	0	8	0	0	6
Spionidae sp. Indet.	Aricidea nr. A. suecica	0	1	6	8		1	9	0	9	0	0	8
Laonice cirrata  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Levensenia gracilis	8	8	8	0		9	8		0	9	0	6
Polydora sp. Indet.	Spionidae sp. Indet.	8	0	8	. 8		0	8	0	9	8	9	0
Polydora socialis	Laonice cirrata	0	8	8	0		8	9	9	0	0	0	0
Polydora pygidialis         8         3         4         8         15         1         8         9         8         1         2           Polydora brachycephala         6         6         6         8         8         8         8         9         8         9	Polydora sp. Indet.	8		8	0		8	8		9	9	8	0
Polydora brachycephala         6         7         39           Prionospio steenstrupi         3         5         6         6         8         15         8         9         9         22         17         39           Prionospio steenstrupi         8         8         2         8         9         8         9         8         9 <t< td=""><td>Polydora socialis</td><td>1</td><td>9</td><td>0</td><td>8</td><td>, .</td><td>• 1</td><td>0</td><td>. 0</td><td>9</td><td>4</td><td>3</td><td>7</td></t<>	Polydora socialis	1	9	0	8	, .	• 1	0	. 0	9	4	3	7
Polydora brachycephala         8         8         8         8         8         8         8         8         8         8         8         8         8         8         9         8         9	Polydora pygidialis	8	3	4	9		15	1		9		1	è
Polydora cardalia         8         1         8         8         1         8         8         1         1           Prionospio steenstrupi         3         6         6         8         15         8         8         22         17         39           Prionospio lighti         8         8         2         8         2         1         8         9         3         1         5           Spio sp. Indet.         2         1         8         1         4         8         8         8         9         8         8         9         8         8         8         9         8         8         9         9         8         8         9	Polydora brachycephala	•	8	8	9	•	8	8	8	8	8	9	9
Prionospio steenstrupi         3         6         6         8         15         8         9         8         22         17         39           Prionospio lighti         8         8         2         6         2         1         8         8         3         1         5           Spio sp. Indet.         2         1         8         1         4         8         8         8         9         8         9         8         9         8         8         9         8         9         8         8         9         8         9         8         9         9         8         9		0	1	9	8		1	. 0		8	8	1	1
Prionospio lighti         0         0         2         0         2         1         0         0         3         1         5           Spio sp. Indet.         2         1         0         1         4         0 <t< td=""><td></td><td>3</td><td>6</td><td>6</td><td>8</td><td>•</td><td>15</td><td>8</td><td>. 0</td><td>8</td><td>22</td><td>17</td><td>39</td></t<>		3	6	6	8	•	15	8	. 0	8	22	17	39
Spio sp. Indet.         2         1         0         1         4         0		8	9	5	0		2	1	8	9		1	5
Spio filicornis         0         1         2         0		2	1	0	1		4	8	8	8	9	9	9
Spio butleri         8         9         3         8         3         6         6         6         6         1         1           Boccardia pugettensis         0         <	Spio filicornis	9	9	0	0		•	8	ā	9	9	9	. A
Boccardia pugettensis         0	Spio butleri	8	0	3	. 8		3	8	ā	9	ā	1	ĭ
Spiophanes bombyx         0         0         6         2         8         0         0         0         0         0           Spiophanes berkeleyorum         0		0	9	ā	9			Ā	A	a	A	â	
Spiophanes berkeleyorum         0		0	ā	_	ą		A	a	a	a	A	a	A
Pygospio elegans         0		0	0	<del>-</del>	ā	•	a	,a	a	\ <b>Q</b>	2	: U	و و
Paraprionospio pinnata 0 0 1 0 1 3 0 0 2 0 5		9	ā	á	a		a	a	.0			A	<u>.                                    </u>
		å	a	1	· g		1	. 3	Ω.	. 0	-	۵	5
		Q	_	a	a		a		۵	3		a	2

ASARCO STATIONS - RAW BIOLOGICAL DAT TAXON NAME	TA T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-B	16-3-C	16-3-D	T6-3 <b>-</b> €	T6-3-TOT
									<del></del>			
Goniada brunnea	8	0	8		. 1	1	i	1	2	1	4	9
Onuphidae sp. Juv	9	9	9	0	8	9	0	8	8	0	0	0
Onuphis sp. Juv.	8	0	0	0	0	8	9	0	8	0	. 8	0
Onuphis iridescens	0	0	9	8	9	9	9	8	9	8	8	0
Onuphis elegans	9	8	8	0	0	0	2	2	1	5	5	9
Diopatra ornata	2 `	6	5	1	1	15	11	4	5	13	1	34
Lumbrineris sp. Indet.	6	8	2	3	2	13	8	7	9	11	1	36
Lumbrineris cruzensis	0	0	0	0	0	8	0	8	8	8	9	0
Lumbrineris californiensis	0	0	6	0	0	0	0	0	0	8	0	8
Notocirrus californiensis	0	0	0	0	0	0	8	0	8	8	6	0
Dorvilleidae sp. Indet.	0	9	9	8	1	1	0	0	0	8	8	9
Dorvillea pseudorubrovittata	9	8	8	. 0	8	0	9	8	8	0	9	8
Dorvillea japonica	0	8	0	8	0	8	0	8	0	8	0	0
Protodorvillea gracilis	2	9	2	· 1	8	14	1	8	0	1	1	3
Dorvillea rudolphi	0	8	9	0	8	0	0	. 8	8	0	9	0
Dorvillea caeca	. 6	8	0	0	0	0	0	8	0	0	8	0
Laonice pugettensis	1	8	. 8	0	8	1	0	0	2	8	8	5
Leitoscoloplos pugettensis	. 0	3	0	8	9	3	0	0	8	ð	9	0
Naineris uncinata		0	0	8	9	8	0	0	8	0	1	1
Scoloplos acmeceps	0	8	9	8	0	0	0	8	8	0	9	9
Paraonidae sp. Indet.	1	0	8	•	0	1	0	8	8	0	0	0
Aricidea nr. A. suecica	2	1	0	8	8	3	1	0	1	9	0	2
Levensenia gracilis	0	1	0	8	0	1	1	6	9	8	9	1
Spionidae sp. Indet.	8	1	8	8	8	1	0	8	0	1	0	1
Laonice cirrata	. 0	0	8	. 8	0	0	9	8	0	0	0	0
Polydora sp. Indet.	1	8	. 5	3	2	. 8	8	0	8	0	0	0
Polydora socialis	8	8	16	6	7	45	4	2	5	50	1	32
Polydora pygidialis	0	8	8	0	9	8	1	9	, 2	13	6	25
Polydora brachycephala	120	8	1	0	0	121	0	0	· 8	0	0	e
Polydora cardalia	0	34	15	- 131	85	265	. 3	23	7	4	9	37
Prionospio steenstrupi	9	5	4	4	0	19	31	23	15	15	14	98
Prionospio lighti	2	0	12	2	0	16	5	5	0	11	0	15
Spio sp. Indet.	8	8	6	9	0	0	0	8	0	0	0	8
Spio filicornis	0	0	0	0	0	8	1	9	1	0	0	2
Spio butleri	0	0	8	1	0	1	0	0	1	0	8	. 1
Boccardia pugettensis	9	Ø.	8	0	0	0	ð	0	1	0	8	1
Spiophanes bombyx	0	8	8	0	0	0	1	0	0	1	8	a
Spiophanes berkeleyorum	2	Ø	0	1	1	4	5	2	5	3	8	12
Pygospio elegans	8	1	8	8	1	2	0	8	9	0	0	6
Paraprionospio pinnata	0	0	8	0	. 6	0	1	8	1	1	i	4
Magelona longicornis	8	0	0	8	8	0	1	1	1	0	1	4

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ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T8-4-A	T8-4-B	T8-4-C	T8-4-D	T8-4-E	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
							**					
Goniada brunnea	9	0	0	2	1	3	0.	0	. 0	0	. 0	8
Onuphidae sp. Juv	0	0	0	0	0	9	0	0	0	0	0	0
Omuphis sp. Juv.	0	0	9	0	8	0	0	9	0	Ø	9	❷.
Onuphis iridescens	0	0	8	0	9	9	0	0	0	8	. 6	0
Onuphis elegans	1	1	2	0	0	4	8	0	0	8	0	•
Diopatra ornata	5	7	18	19	12	61	0	0	1	1	1	3
Lumbrineris sp. Indet.	6	11	<b>, 3</b>	7	8	35	8	1	8	0	8	1
Lumbrineris cruzensis	0	1	0	0	6	1	0	. 0	0	0	0	8
Lumbrineris californiensis	. 0	0	0	0	9	0	9	0	0	8	0	8
Notocirrus californiensis	0	1	8	0	. 0	1	. 8	0	0	0	8	6
Dorvilleidae sp. Indet.	0	8	0	8	0	9	0	0	8	0	0	0
Dorvillea pseudorubrovittata	0	0	ð	9	8	9	5	1	0	0	0	3
Dorvillea japonica	0	0	8	9	8	0	0	0	0	0	0	0
Protodorvillea gracilis ,	0	0	0	0	8	0	0	0	. 0	. 0	9	9
Dorvillea rudolphi	0	1	0	1	2	4	0		0	0	0	0
Dorvillea caeca	0	0	8	6	9	0	0	0	8	0	0	8
Laonice pugettensis	1	0	8	0	0	1	0	0	. 0	0	0	9
Leitoscoloplos pugettensis	0	8	0	8	0	0	0	9	8	9	0	0
Naineris uncinata	0	0	0	0	1	1	0	0	0	0	0	0
Scolopios acmeceps	. 1	8	0	8	0	1	8	8	8	8	0	0
Paraonidae sp. Indet.	9	8	0	0	0	0	8	. 0	0	0	9	0
Aricidea nr. A. suecica	1	0	8	0	0	- 1	9	0	8	0	0	0
Levensenia gracilis	9	0	0	9	9	0	0	0	8	8	0	8
Spionidae sp. Indet.	8	0	0	8	0	0	0	8	0	0	0	8
Laonice cirrata	8	0	0	1	1	2	•	0	8	8	. 0	8
Polydora sp. Indet.	0	0	8	0	9	0	0	. 8	8	0	0	8
Polydora socialis	8	16	5	4	22	55	28	34	17	17	13	109
Polydora pygidialis	9	19	5	6	6	45	34	64	29	45	40	515
Polydora brachycephala`		8	8	1	0	1	9	7	6	19	13	54
Polydora cardalia	14	35	1	0	3	53	0	9	0	8	8	_ 0
Prionospio steenstrupi	14	30	26	13	10	93	3	6	0	6	0	3
Prionospio lighti	5	1	3	1	1	8	14	39	10	8	- 13	84
Spio sp. Indet.	0	0	0	6	0	8	0	0	9	8	9	8
Spio filicornis	0	0	9	2	0	5	0	0	0	0	0	8
Spio butleri	1	0	9	8	0	1	0	8	8	0	9	0
Boccardia pugettensis	0	9	9	0	8	9	1	0	0	8	0	1
Spiophanes bombyx	0	1	0	0	0	1	. 6	0	0	8	0	0
Spiophanes berkeleyorum	0	3	0	9	0	3	9	9	8.	0	8	0,
Pygospio elegans	5	0	0	Ö	0	2	0.1	0	0	0	. 0	❸ ,
Paraprionospio pinnata	0	1	0	0	6	1	9	9	0.	9	0	. 6
Magelona longicornis	0	0	1	8	0	1	9	8	9	Ģ	0	0

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-E	T11-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-TOT
Goniada brunnea	0	8	. 1	8	8	1		8		0	8	
Onuphidae sp. Juv	9	8	. 0	8	0	9	0	8	8	8	8	0
Unuphis sp. Juv.	0	0	9	0	8	. 0	8	8	0	0	0	0
Onuphis iridescens	0	0	0	8	9	9	8	8	9	ð	8	0
Onuphis elegans	0	0	9	0	8	0	0	. 8	8	8	8	0
Diopatra ornata	8	8	. 2	0	.0	10	8	9	0	8	8	8
Lumbrineris sp. Indet.	8	1	8	0	0	1	8	8	0	1	8	1
Lumbrineris cruzensis	0	0	8	0 .	6	•	9	8	8	8	0	9
Lumbrineris californiensis	8	0	0	6	8	0	8	8	0	0	0	9
Notocirrus californiensis	0	0	0	8	8	8	8	Ģ	9	Q	9	0
Dorvilleidae sp. Indet.	8	8	9	8	0	8	8	9	0	0	6	9
Dorvillea pseudorubrovittata	8	0	0	. 8	. 8	8	0	•		9	0	0
Dorvillea japonica	8	0	0	0	B	8	9	6	9	9	8	U
Protodorvillea gracilis	8	0	0	0	0	0	0	8	0	9	V	V
Dorvillea rudolphi	8	0	9	8	9	9	9		y	v	8	9
Dorvillea caeca	8	0	9	8	0	9	8	8	9	9	6	0
Laonice pugettensis	8	0	8	8	8	8	8	8			Ų	Ø
Leitoscoloplos pugettensis	2	8	9	8	0	2	8	9	6	0	V	0
Naineris uncinata	8	0	8	6	8	8	e e	8	8	8	0	0
Scoloplos acmeceps	8	0	0	6	9	9	9	8		0	0	0
Paraonidae sp. Indet.	0	8	9			0	U	. 8			, p	9
Aricidea nr. A. suecica	8	9	5	4	1	10	U		4			0
Levensenia gracilis	8	9	9	9	U	8	9	ß	9	0	6	
Spionidae sp. Indet.	. 0	U	9	U	9	9	9				0	0
Laonice cirrata		, 0	V	v	0			v	9	W A	9	
Polydora sp. Indet.		V		U			20	<b>19</b>	8	75	5	74
Polydora socialis	1	ь.			1	8	20	8	D 2	35	3	74
Polydora pygidialis		4	•	<b>v</b>		4	9	1	•	1		
Polydora brachycephala Polydora cardalia		. 1	9	•		9 9	3	4	1		1	11
Prionospio steenstrupi	14	20	27	17	13	91	8	0 0	Φ Δ	1	4	i a
Prionospio lighti	14	8	8	1/ A	13	8	33	D D	7	28	Δ	68
Spio sp. Indet.	Ä	0	8	9	9	0	9	a	a	6	a a	a
Spio filicornis	a	a	0 0	ă	A	A	A	a	a	a	a	a
Spio butleri	a	A	a	Ā	a	A	A	a	A	a	ρ	a
Boccardia pugettensis	g g	à	9	9	A	a	À	. 0	9	Ω.	Д	a
Spiophanes bombym	a	9	a	0	a	0	0	9	a	a	A	a
Spiophares berkeleyorum	ā	9	Ď	2	9	8	0	0	ā	0	9	8
Pygospio elegans	9	ě	9	0	2	0	9	ě	ě	0	9	8
Paraprionospio pinnata	ě	9	ē	8	8	9	9	9	0	ě	ě	8
Magelona longicornis	0	0	9	0	ā	0	0	ā	ā	0	a	

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T16-1-A	T16-1-B	T16-1-C	T16-1-D	T16-1-E	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	T16-4-D	T16-4-E	T16-4-TOT
		**********										
Goniada brunnea	1	1	8	8	0	5	0	8	0	2	. 0	2
Onuphidae sp. Juv	9	0	9	0	1	1	0	8	0	0	0	0
Onuphis sp. Juv.	0	0	0	9	8	0	0	0	0	0	0	0
Onuphis iridescens	i	0	9	3.	0	4	0	2	9	9	0	2
Onuphis elegans	2	1	0	0	1	4	0	. 0	0	9	1	1
Diopatra ornata	6	5	5	7	9	32	6	3	1	1	5	13
Lumbrineris sp. Indet.	3	4	1	1	4	13	3	9	6	2	3	8
Lumbrineris cruzensis	9	0	9	9	. 0	9	0	9	9	9	0	9
Lumbrineris californiensis	0	0	9	9	. 0	9	9	0	0	0	0	0
Notocirrus californiensis	1	8	8	1	0	5	8	0	0	6	0	9
Dorvilleidae sp. Indet.	8	0	0	9	0	0	0	0	0	0	0	0
Dorvillea pseudorubrovittata	0	0	9	8	0	9	0	9	0	0	0	9
Dorvillea japonica	9	8	0	0	0	8	0	9	9	8	0	0
Protodorvillea gracilis	5	8	3	0	0	5	0	0	0	0	0	0
Dorvillea rudolphi	9	9	8	0	0	8	0	0	0	9	0	0
Dorvillea caeca	8	0	9	0	6	8	0	8	. 0	9	0	9
Laonice pugettensis	5	9	9	0	0	2	8	0	0	1	0	1
Leitoscoloplos pugettensis	1	4	1	1	2	9		•	0	2	1	3
Naineris uncinata	8	0	8	0	8	8	8	. 0	0	0	8	0
Scoloplos acmeceps	0	0	0	0	9	9	2	. 0	8	0	8	2
Paraonidae sp. Indet.	0	0	0	0	8	. 6	0	8	0	0	0	0
Aricidea nr. A. suecica	8	9	9	.1	. 8	1	1	. 6	0	0	1	2
Levensenia gracilis	9	0	8	8	0	9	9	8	. 0	0	0	0
Spionidae sp. Indet.	9	9	9	9	0	0	9	•	0	9	9	9
Laonice cirrata	8	9	0	8	0		9	0	0	0	1	1
Polydora sp. Indet.	8	0	. 0	0			0	0	8	0	0	9
Polydora socialis	21	12	11	40	40	124	1	0	1	3	2	7
Polydora pygidialis	6	8	9	3	0		9	9	9	0	0	
Polydora brachycephala	ā	4	5	1	4	14	ē	5	9	1	6	14
Polydora cardalia	1	ė	9	1	4	. 6	0	9	9	9		
Prionospio steenstrupi	92	66	131	. 86	80	_	, 23	21	10	42	30	126
Prionospio lighti	7.	1	9	1	1	_	, 20		a		A	
Spio sp. Indet.	<u>a</u>	å	Δ	a	A	-	Δ	A	A	a	a	
Spio filicornis	7	a	5	<u> </u>	1	9		<u>a</u>	ā	ă	a	
Spio butleri		e 4	a J	<u>a</u>	1	, a	Δ	Δ	<u>a</u>	1	<u> </u>	•
Boccardia pugettensis	<b>.</b>	0	9	0 0	0	) 6	Φ		. 4	1	0	
	•	4	_			·	0		Φ Δ	0 A	9	_
Spiophanes bombyx		1	5 8	2		12		<b>6</b>	2.	0 a	2	-
Spiophanes berkeleyorum	3	2		2			1	4	ζ. Δ	Δ.	a	
Pygospio elegans	9	8	0				4	4	Ø:	<b>U</b> :		
Paraprionospio pinnata		U	1	4		1 14	4	1		a	i	
Magelona longicornis	7	0	2	1	e	10	1	V	0	V	W.	) ·

ASARCO STATIONS - RAN BIOLOGICAL D	ATA												1	GRAND
TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-TOT	T22-2-A 	T22-2-B	T22-2-C	T22-2-D 	T22-2-E	T22-2-TOT	 	TOTAL
Goniada brunnea	9	· 0		0	0	0	10	0	0	0		0	1	26
Onuphidae sp. Juv	9	0	. 8	8	0	0	0	0	0	8	0	0	1	1
Onuphis sp. Juv.	. 8	0	0	0	1	1	0	0	9	0		9		1
Onuphis iridescens	0	0	0	9	0	0	2	9	0	8	0	2	- 1	8
Onuphis elegans	0	0	0	8	0	9	0	0	0	. 9	8	0	1	18
Diopatra ornata	5	3	4	0	2	11	9	8	2	-2	2	23		278
Lumbrineris sp. Indet.	66	36	67	54	48	271	31	29	35	32	36	163	1	545
Lumbrineris cruzensis	8	0	8	8	0	0	0	8	8	6	0	0	1	1
Lumbrineris californiensis	. 7	8	5	5	8	14	5	0	1	9	8	11	1	25
Notocirrus californiensis	0	0	0	0	8	0	0	0	8	0	0	0	i	3
Dorvilleidae sp. Indet.	9	8	0	0	0	0	1	1	Ģ	. 8	0	5	i	3
Dorvillea pseudorubrovittata	8	8	8	8	. 8	9	0	0	0	0	0	0	-	3
Dorvillea japonica	4	1	2	9		7	2	1	4	0	14	21	-	28
Protodorvillea gracilis	12	23	41	10	8	94	8	4	2	5	1	20		136
Dorvillea rudolphi	1	0	. 0	1	9	5	8	9	0	0	1	•	1	10
Dorvillea caeca	8	1	0	8	0	1	0	2	0	9	1	3	•	4
Laonice pugettensis	17	6	11	11	10	55	5	6	1	5	3	17	ł	81
Leitoscoloplos pugettensis	4	0	0	8	8	4	9	8	9	8	0	0	ı	21
Naineris uncinata	0	. 8	0	0	0	9	0	9	9	0	0	8	ı	5
Scolopios acmeceps	0	8	0	8	9	0	9	0	6	0	0	0	ı	3
Paraonidae sp. Indet.	9	8	. 0	Ģ	0	6	0	0	9	8	8	6	1	1
Aricidea nr. A. suecica	0	9	. 6	6	0	0	1	1	8	0	0	5	1	55
Levensenia gracilis	0	8	0	0	0	8	1	0	1	8	0	5	ı	4
Spionidae sp. Indet.	0	0	0	0	0	0	0	1	0	1	1	3	ı	5
Laonice cirrata	9	9	9	9	8	0	8	0	0	5	9	5	1	5
Polydora sp. Indet.	2	8	0	1	8	3	1	3	4	1	5	14		25
Polydora socialis	23	7	8	4	5	47	15	11	7	28	5	63	-1	572
Polydora pygidialis	3	5	9	4	5	23	0	1	1	1	3	6	1	349
Polydora brachycephala	1	8	. 0	0	9	1	5	9	18	0	11	31	1	249
Polydora cardalia	8	0	0	9	2	2	0	8	0	0	0	0	ı	366
Prionospio steenstrupi	205	246	115	107	250	920	134	139	77	52	142	544	1	2403
Prionospio lighti	124	72	43	37	114	390	47	44	115	19	121	346	i	940
Spio sp. Indet.	9	6	0	0	0	8	0	0	0	8	0	Ø	ı	4
Spio filicornis	0	0.	0	0	0	0	0	8	0	9	0	0	ı	13
Spio butleri	0	0	0	0	0	0	0	Ø	0	0	0	0	1	8
Boccardia pugettensis	0	0	0	0	0	9	8	0	0	9	B	0	ļ	2
Spiophanes bombyx Spiophanes berkeleyorum	<b>8</b> 4	<b>8</b> 2	<b>8</b> 1	9	9	9 10	<b>0</b>	<b>0</b>	0 12	<b>0</b> 3	0 10	<b>8</b> 29	-	12 77
Pygospio elegans	ā	8		a	â	.0	ā	0		9	.0	0	i	4
Paraprionospio pinnata	a	1	2	1	3	7	1	1	2	8	1	5	i	26
· · · · · · · · · · · · · · · · · · ·	٥	_		a a	_	•	a	e O			-	-	i	19
Magelona longicornis	0	0	0	8	0	0	0	8	Ø	0	0	9	i	19

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ASARCO STATIONS - RAW BIOLOGICAL DATA	70 5 0	T0 F D	TO 5 5	TO C D	<b>TA 5 5</b> TA		T3 = A	<b>73 C D</b>	<b>73.5.5</b>	73 F B	T3 C C	73 5 707
TAXON NAME	T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-E T2-	-5-TOT	T3-5-A	T3-5-B	T3-5-C	T3-5-D	13-5-E	T3-5-TOT
Trochochaeta multisetosa	0	0	9	0		0	0	0	8	0	0	
Chaetopteridae sp. Indet.	0	0	8	8		8	8	8	8	0	8	8
Spiochaetopterus costerum	3	3	0	9		6	8	0	0	11	2	13
Mesochaetopterus taylori	9	0	9	0		0	8	0 ,	8	9	8	0
Cirratulidae sp. Indet.	9	0	0	8		9	0	/ <b>Ø</b> ·	8	1	0	1
Cirratulus cirratus	5	7	9	0		9	9	0	9	4	4	8
Cirratulus spectabilis	8	8	8	8		8	8	•	9	8	8	8
Caulleriella sp. Indet.	0	0	0	8		9	0	8	8	0	8	0
Caulleriella hamata	8	1	2	8		'3	9	0	0	1	1	2
Tharyx sp. Indet.	0	0	0	0		. 0	8	0	8	0	0	8
Tharyx multifilis	2	1	1	0		4	0	0	8	3	1	4
Chaetozone sp. 1	0	0	9	•		0	0	0	0	0	0	. 8
Chaetozone sp. Indet.	0	0	1	8		1	0	•	1	8	0	1
Chaetozone setosa	0	9	0	0		9	8	0	8	0	8	0
Brada villosa	9	0	0	8		9	0	0	0	. 0	0	8
Pherusa plumosa	0	0	8	0		0	0	0	0	9	9	0
Opheliidae sp. Indet.	· 0	0	0	9		0	8	8	0	9	0	8
Ophelina acuminata	0	9	0	0		0	0	0	8	. 8	8	8
Ophelina breviata	. 5	1	2	3		8	0	0	8	1	0	1
Armandia brevis	0	0	9	8		8	8	0	. 8	0	2	2
Capitella capitata complex	0	9	0	8		0	0	0	8	8	0	8
Heteromastus sp. Indet.	0	0	0	0		0	9	0	8		. 0	8
Notomastus tenuis	1	0	1	0		2	1	3	26	10	1	41
Notomastus lineatus	0	0	8	8		8		0	0	0	9	0
Mediomastus sp. Indet.	0	2	•	1		3	1	3	3	7	1	15
Mediomastus californiensis	2	0	0	6		2	0	8	0	8	9	•
Decamastus gracilis	8	0	0	1		1	0	8	0	0	0	8
Barantolla americana	1	0	1	0		2	9	8	8	8	. 0	0
Maldanidae sp. Indet.	9	0	0	8		0	0	9	4	0	9	4
Euclymininae sp. Indet.	0	0	0	0			. 0	. 0	8	, . <b>8</b>	<b>8</b>	, , , 9
Asychis similis	•	0	. 6	8		0	. 8		8		9	8
Maldane glebifex	0	2	0	0		2	1	9	0	0	9	1
Nicomache personata	0	0	9	9		0	8	9	0	8	0	0
Notoproctus pacificus	0	9	9	9		0	8	•	0	0	0	0
Praxillella affinis pacifica	0	0	0	0	•	0	0	9	8	0	. 8	8
Rhodine bitorquata	9	0	0	9		8	0	0	0	2	1	3
Euclymene ?zonalis	0	0	0	0	,	0	0	0	0	-0	0	.0
Clymenura colulmbiana	9	. 0	0	0	٠.	8	9	9	.0		0	, 0
Owenia fusiformis	8	0	0	0		0	8	0	0	2	0	2
Myriochele heeri	0	9	ġ,	ē		0	Ā	9	í	9	0	0
Galathowenia oculata	9	1	a	ě		1	9	í	1	1	1	Ā
PROSSILANDISE APROMAN	•	•	•	~		•	v	•	•	•	•	•

ASARCO STATIONS - RAW BIOLOGICAL DAT TAXON NAME	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-B	76-3-C	T6-3-D	76-3-€	T6-3-TOT
	_	_	_	_			_	_	_	_		_
Trochochaeta multisetosa	8	0	0	0	0	. 8	9	9		0	8	9
Chaetopteridae sp. Indet.	<b>8</b>		. U	2	. 8	5	V	<b>V</b>	1	<b>16</b>		1
Spiochaetopterus costerum	,	11 0	13	14	11 0	56 0	3	16		15	1	40
Mesochaetopterus taylori		<b>8</b>	0	0		2	ı	3	ı		0	, b
Cirratulidae sp. Indet.	2 م			•		_	<b>0</b>	3 2		1	0	4
Cirratulus cirratus	. O	3	Þ	<u>د</u>	ı A	12		<u>د</u> م	3	0		11
Cirratulus spectabilis			0	•			<b>U</b>		Ø		0	
Caulleriella sp. Indet.		0				•		8				
Caulleriella hamata	1	3		1		5	1	3	i	1	9	6
Tharyx sp. Indet.	1	8	6		. 1	16	U	9	8			40
Tharyx multifilis	9	U	10	5	Ø	12	1	3	2	1	8	10
Chaetozone sp. 1	0	0	9	9	9	9	U	8		<b>U</b>	9	9
Chaetozone sp. Indet.		0				. 6				0		
Chaetozone setosa	1	V	0	1	0	2	1	1	1		1	4
Brada villosa		U	U		U	0		0	8	0	0	V
Pherusa plumosa	5	2	1	1	9	9	V		U	U	U	
Opheliidae sp. Indet.	11	0	9	3	9	23	0	0	0	9	0	0
Ophelina acuminata	0	9	0	8	0	0	9	Ø	0	0	0	0
Ophelina breviata	0	0	1	0	8	1	0	0	0	0	0	
Armandia brevis	9	9	0	0	0	0	0	1	2	1	9	4
Capitella capitata complex	1	0	0	8	0	1	0	0	0	0	0	0
Heteromastus sp. Indet.	8	8	. 0	0	0	8	9	Ģ	1	8	8	1
Notomastus tenuis	0	8	9	1	1	2	0	1	3	8	3	7
Notomastus lineatus	1	0	Ø	8	0	1	8	8	8	Ģ	9	0
Mediomastus sp. Indet.	. 0	2	6	3	5	16	0	0	8	Ģ	8	8
Medicmastus californiensis	0	0	9	ø	0	9	4	4	3	3	1	15
Decamastus gracilis	0	0	0	0	0	8	0	0	0	. 0	9	9
Barantolla americana	0	0,	0	0	9	8	9	0	0	0	1	1
Maldanidae sp. Indet.	1	1	3 .	6	. 3	14	2	2	1	1	8	6
Euclymininae sp. Indet.	9	0	0	9	9	9	0	0	1	9	0	1
Asychis similis	0	0	0	0	0	0	9	0	0	0	8	8
Maldane glebifex	0	8	9	0	8	0	2	1	5	7	8	15
Nicomache personata	1	1	2	Ó	0	4	0	9	0	0	0	8
Notoproctus pacificus	0	0	0	0	0	0	9	0	8	8	0	0
Praxillella affinis pacifica	0	0	0	0	0	8	Ø	0	0	0	8	8
Rhodine bitorquata	8	9	0	0	. 0	0	1	. 1	0	0	0	5
Euclymene ?zonalis	0	0	0	0	0	0	9	0	0	9	3	. 3
Clymenura colulmbiana	8	0	9	9	0	9	8	9	6	1	0	1
Owenia fusiformis	5	5	7	14	14	45	4	1	1	7	1	14
Myriochele heeri	0	8	9	. 0	0	0	0	0	0	0	0	6
Galathowenia oculata	0 .	0	0	1	1	2	8	0	4	1	0	5

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ASARCO STATIONS - RAW BIOLOGICAL DATA				_								
TAXON NAME	T8-4-A	T8-4-B	TB-4-C	T8-4-D	T8-4-E	T8-4-TOT	T18-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
Trochochaeta multisetosa	0	0	0	0			0	0	0	0	8	0
Chaetopteridae sp. Indet. Spiochaetopterus costerum	<b>9</b> 57	2 64	0 18	<b>8</b> 13	0 46	2 198	<b>0</b> 8	<b>8</b> 6	<b>8</b> 18	<b>6</b> 4	<b>0</b> 2	9 39
Mesochaetopterus taylori Cirratulidae sp. Indet.	0 0	<b>0</b> 3	<b>9</b> 3	3 4	<b>0</b>	5 10	<b>8</b>	0	<b>0</b>	<b>9</b> 0	0 0	0
Cirratulus cirratus Cirratulus spectabilis	4 0	<b>0</b>	9	<b>6</b> 5	8 0	<b>2</b> 3	- 102 1	83 0	196 8	83 1	82 8	456 2
Caulleriella sp. Indet. Caulleriella hamata	<b>8</b> 8	9	<b>8</b>	9 8	9	<b>0</b> 2	9	0 8	. <b>9</b>	<b>8</b>	0 8	8
Tharyx sp. Indet. Tharyx multifilis	9	. 0	9	9	8	<b>0</b> 17	9	9	<b>8</b> 4	<b>0</b>	· 0	0
Chaetozone sp. 1	9	9	3	5	3	8	17	13	6	6	1 <b>0</b>	52
Chaetozone sp. Indet. Chaetozone setosa	9	9	0	8	8	0	9	9	. 6	9	0	0
Brada villosa Pherusa plumosa	8	8	8	8	1	1	0	8	0	0	9	0
Opheliidae sp. Indet. Ophelina acuminata	8 9	9 9	8	8 9	6 9	6 6	0 8	<b>8</b>	<b>6</b> 0	0 0	8	0 0
Ophelina breviata Armandia brevis	<b>8</b> 9	0	3 0	6 1	i 0	10 1	<b>6</b> 46	8 29	<b>0</b> 39	9 59	<b>e</b> 32	196
Capitella capitata complex Heteromastus sp. Indet.	0 0	0 0	<b>e</b> 9	6 8	0 0	0 0	34 0	31 0	34 0	31 <b>0</b>	24 0	154 0
Notomastus tenuis Notomastus lineatus	1	<b>2</b>	1 0	2 1	<b>6</b>	6 1	0 A	0 9	0 R	6 A	8 a	0 . a
Mediomastus sp. Indet. Mediomastus californiensis	1	3	0	2	0	6	0 11	Ø 11	. 0	9	0	Ø 28
Decamastus gracilis Barantolla americana	0	0	9	9	9	8	8	0	9	8	0	8
Maldanidae sp. Indet.	. 1	8	9	8	9	1	8	8	8,	8	0	9
Euclymininae sp. Indet. Asychis similis	<b>8</b>	8	0	<b>6</b> 5	9	0	9	9	0	8	0	9
Maldane glebifex Nicomache personata	9 33	<b>9</b> 8	0	0 1	<b>0</b>	<b>8</b> 42	8	0	8	• 0	<b>0</b>	0 0
Notoproctus pacificus Praxillella affinis pacifica	<b>8</b>	9	0 0	<b>0</b>	1	10 8	0 0	<b>9</b> 0	0 0	0 8	9	0
Rhodine bitorquata Euclymene ?zonalis	0	0 0	0 0	0 0	9 8	<b>0</b>	<b>9</b> 0	0 8	9 0	<b>0</b>	8 0	9
Clymenura colulmbiana Owenia fusiformis	1 2	9	0,	0 a *	0.	1	0	0	9 9	6	8	8
Myriochele heeri Galathowenia oculata	9	9	0	0	9	0	9	8	0	9	. 8	9

ASARCO STATIONS - RAW PIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	T11-7-C	T11-7-D	711-7-€	T11-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-TOT
Trochochaeta multisetosa	8	0	0	0	0	8	8	0	8	0	0	8
Chaetopteridae sp. Indet.	0	<b>e</b> .	. 0		. 8	9	0	9	0	8	0	8
Spiochaetopterus costerum	1	6	9	2	8	9	3	8	9	0	0	3
Mesochaetopterus taylori	8	0	8	1	8	1	8	8	0	8	0	8
Cirratulidae sp. Indet.	0	0	8	8	0	8	0	8	8	0	0	0
Cirratulus cirratus	8	0		8	9	9	8	52	37	9	1	197
Cirratulus spectabilis	9	Ó	0	8	0	9	8	0	0	0	8	0
Caulleriella sp. Indet.	0	9	9	9	8	8	0	8	8	0	9	0
Caulleriella hamata	0	1	8	8	0	1	2	8	0	0	0	. 2
Tharyx sp. Indet.	0	4	9	8	0	4	0	8	0	9	0	9
Tharyx multifilis	2	2	9	8	9	4	2	2	4	0	0	8
Chaetozone sp. 1	1	9	1	1	9	3	8	8	0	ė	0	8
Chaetozone sp. Indet.	8	0	9	. 6	9	8	0	8	8	0	8	0
Chaetozone setosa	8 '	9	0	8	0	0	3	8	8	1	8	4
Brada villosa	0	0	8	0	8	8	8	8	9	0	0	8
Pherusa plumosa	0	8	0	9	9	0	9	8	0	0	8	8
Opheliidae sp. Indet.	. 8	0	9	0	0	0	0	0	0	8	8	8
Ophelina acuminata	9	0	0	8	9	9	9	0	8	0	9	
Ophelina breviata	0	8	0	1	9	1	0	0	0.	0	0	
Armandia brevis	9	9	8	8	8	0	15	1	9	32	26	74
Capitella capitata complex	0		0	0	9	0	1188	13	2	2133	1178	4514
Heteromastus sp. Indet.	0	0	9	8	9	8	0	0	9	8	0	8
Notomastus tenuis	1	0	0	0	0	1	0	8	0	0	0	0
Notomastus lineatus	9	8	9	8	0	0	0	8	9	0	0	8
Mediomastus sp. Indet.	. 0	0	0	1	0	1	8	8	0	9	0	8
Medicmastus californiensis	9	0	0	9	8	9	0	9	0	0	1	i
Decamastus gracilis	0	9	9	. 0	9	0	Õ	0	ē	0	0	8
Barantolla americana	9	9	ù	8	0	0	9	1	0	0	9	1
Maldanidae sp. Indet.	0	8	1	0	0	1	0	8	0	é	0	0
Euclymininae sp. Irdet.	0	1	0	0	1	2	0	0	9	8	8	0
Asychis similis	0	9	0	0	6	0	0		0	0	0	0
Maldane glebifex	0	0	0	0	0	0	0	0	8	9	8	0
Nicomache personata	ē	ð	1	ē	9	i	ě	9	9	9	8	0
Notoproctus pacificus	<b>a</b>	0	9	0	8	8	0	9	e	ē	0	0
Praxillella affinis pacifica	0	0	. 0	0	0	9	9	9	9	0	0	8
Rhodine bitorquata	0	0	9	8	8	. 8	8	0	9	9	0	9
Euclymene ?zonalis	0	ō	0	0	0		9	ē	<u>.</u>	0	9	0
Clymerura colulmbiana	0	0	Õ	1	9	1	0	9	9	Õ	9	0
Owenia fusiformis	0	0	0	0	0	ø	0	Ð	8	0	0	0
Myriochele heeri	0	0	0	0	0	0	0	0	0	0	. 0	8
Galathowenia oculata	0	Ø	2	9	Ŋ.	0	0	9	Ā	ð	0	ā

ASARCO STATIONS - RAW BIOLOGICAL DATA												
TAXON NAME	T16-1-A	T16-1-B	T16-1-C	T16-1-D	T16-1-€	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	T16-4-D	T16-4-E	T16-4-TOT
Trochochaeta multisetosa	0	0	0	0	0	8	8	8	0	0	0	8
Chaetopteridae sp. Indet.	0	8	0	8	8	0	Ö	8	Ö	Õ	Ö	0
Spiochaetopterus costerum	11	2	6	4	11	34	1	0	1	1	1	4
Mesochaetopterus taylori	7	2	4	9	3	16	0	0	9	9	9	0
Cirratulidae sp. Indet.	0	0	9	8	0	8	0	0	0	0	8	0
Cirratulus cirratus	8	6	0	12	4	16	8	9	0	9	9	0
Cirratulus spectabilis	0	0	0	8	0	8	0	6	0	9	0	0
Caulleriella sp. Indet.	1	9	8	0	9	1	9	1	9	0	8	1
Caulleriella hamata	8	0	2	0	8	2	9	9	8	1	0	1
Tharyx sp. Indet.	· 3	8	0	8	6	3	0	8	9	0	6	0
Tharyx multifilis	13	5	14	6	10	48	2	1	1	3	1	8
Chaetozone sp. 1	8	. 9	8	8	8	8	8	8	8	8	8	8
Chaetozone sp. Indet.	9	0	0	. 6	6	8	0	8	0	8	9	0
Chaetozone setosa	2	3	1	1	2	9	9	5	9	9	9	5
Brada villosa	9	0	8	•	0	0	0	0	8	0	0	0
Pherusa plumosa	8	9	9	9	8	0	8	9	9	0	0	9
Opheliidae sp. Indet.	0	9	1	0	0	1	1	0	1	8	2	4
Ophelina acuminata	9	9	0	8	9	0	8	9	9	9	2	2
Ophelina breviata	0	0	9	9	8	0	8	8	8	0	0	0
Armandia brevis		9	9	9	9	8	0	0	0	8	0	0
Capitella capitata complex	0	8	8	0	8		0	0	0	0	8	0
Heteromastus sp. Indet.	8	9	9	8	0	9	9	8	9	0	9	0
Notomastus tenuis	42	5	7	9	20	83	4	4	3	7	1	19
Notomastus lineatus	3	3	4	. 2	. 2		1	8	8	8	8	1
Mediomastus sp. Indet.	16	5	11	6	. 11		1	9		i	1	3
Mediomastus californiensis		1	0	8	2			8		0	0	0
Decamastus gracilis		8	9	. 6	9	0	8			8	8	0
Barantolla américana	9	9			8	0	ā	8	. 0	9	0	. 6
Maldanidae sp. Indet.	3	8	2	5	1	11		8	8	1	8	2
Euclymininae sp. Indet.	9	9	9	0	. 6	0	8	0	9	0	9	0
Asychis similis	9	a	9	9	A	Ā	9	9	8	9	9	9
Maldane glebifex	a	9	ā	9	i . A	A	; ;; 6			' @	'' 6	0
Nìcomache personata	a	A	a	Ä	a	ā	A	ā	a	Ä	9	9
Notoproctus pacificus	å	A	a	A	a	a	a	Ã	ā	a	a	a
Praxillella affinis pacifica	a	a	a	a	a	ă	a	a	a	a	1	1
Rhodine bitorquata	Δ.	1	3	A	a	4	a ·	. 2	1	. 1	a	4
Euclymene ?zonalis	9	a	a	<u>.</u>	0	ā	9	ā		å	a	A
Clymenura colulmbiana	<b>a</b>	2	1	9	. 2	, 5	A	1	1	a	· a	۶
Ovenia fusiformis	4	1	1 a	. 2			<u>a</u>	1	ā	A	a	1
Myriochele heeri	0 A	n i	0	2	a		, 1	ı A	1	1	2	ġ
Galathowenia oculata	v •	Ψ Δ	0	. 0	9	· 0	0	' A	1	1	2	1
palatnowenia oculata	v	e e	v	. 0	v	v	v	8	V	1	v	1

TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-TOT	T22-2-A	T22-2-B	T22-2-C	T22-2-D	T22-2-E	T22-2-TOT	ı	TOTAL
Trochochaeta multisetosa	Q	8	8	8	. 9	0	9	1	9	0	0	1	,	1
Chaetopteridae sp. Indet.	9	. 8	ě	9	9	0	0	9	8	. 0	ø	8	i	5
Spiochaetopterus costerum	54	40	23	37	37	191	11	7	8	9	8	35	ł	624
Mesochaetopterus taylori	. 8	1	8	1	8	2	0	0	1	8	1	2	1	32
Cirratulidae sp. Indet.	8	8	3	9		3	8	0	9	8	8	8	ì	20
Cirratulus cirratus	6	4	5	12	4	31	8	8	8	8	5	37	F	710
Cirratulus spectabilis	8	8	0	9	8	0	0	8	0	9	8	0	ł	5
Caulleriella sp. Indet.	0	0	0	0	0	8	9	ð	0	0	9	0	1	5
Caulleriella hamata	12	3	19	6	13	44	4	5	8	0	. 4	21	1	89
Tharyx sp. Indet.	8	8	9	8	0	0	0	0	. 0	0	8	8	ı	23
Tharyx multifilis	5	7	9	5	8	34	31	37	18	14	11	111	ŀ	264
Chaetozone sp. 1	18	3	7	8	17	53	6	8	9	5	3	14	ı	130
Chaetozone sp. Indet.	8	9	9	8	0	9	0	0	0	0	8	0	1	2
Chaetozone setosa	1	9	0	0	8	1.	0	0	0	0	0	8	ı	22
Brada villosa	9	8	0	8	•	. 6	0	0	8	8	0	0	ł	1
Pherusa plumosa	1	0	1	1	. 0	3	1	8	0	. 0	0	1	1	13
Opheliidae sp. Indet.	9	0	0	0	0	9	8	1	14	2	. 0	25	1	53
Ophelina acuminata	1	0	8	8	8	1	8	8	0	0	0	0	ŀ	3
Ophelina breviata	8	0	0	0		8	0	. 9	0	0	0	0	1	21
Armandia brevis	120	123	76	80	196	595	4	7	7	2	1	21	1	893
Capitella capitata complex	1	1	3	0	0	5	0	6	2	1	0	3	ŀ	4677
Heteromastus sp. Indet.	0	9	8	0	0	0	8	0	8	0	0	0	1	1
Notomastus tenuis	12	11	11	8	14	56	11	1	10	8	4	26	1	243
Notomastus lineatus	0	8	. 8	0	0	8	ø	8	0	8	0	8	1	17
Mediomastus sp. Indet.	8	9	0	8	9	0	Ø	0	0	0	0	0	1	93
Medicuastus californiensis	32	13	57	30	64	196	30	22	44	14	35	145	i	392
Decamastus gracilis	0	8	9	9	0	0	0	0	0	0	0	0	1	1
Barantolla americana	2	0	8	. 8	0	2	. 0	2	4	0	0	6	1	12
Maldanidae sp. Indet.	9	0	1	0	0	1	2	2	0	1	2	7	ı	47
Euclymininae sp. Indet.	0	0	0	9	0	8	0	0	0	8	8	0	ł	7
Asychis similis	9	8	0	0	9	0	0	9	0	1	9	1	1	1
Maldane glebifex	0	1	0	8	9	1	0	0	0	9	1	1	1	17
Nicomache personata	0	8	0	0	. 6	8	20	1	1	8	5	35	1	82
Notoproctus pacificus	0	0	0	0	0	8	0	0	0	8	0	8	i	10
Praxillella affinis pacifica	0	0	0	8	0	0	0	ø	0	0	0	0	ı	1
Rhodine bitorquata	8	0	8	0	8	0	9	0	0	0	8	9	1	13
Euclymene ?zonalis	8	0	0	0	8	0	0	0	0	0	5	2	j	5
Clymenura colulmbiana	0	0	0	0	0	0	0	0	0	0	0	9	ł	10
Owenia fusiformis	9	0	0	8		0	0	9	8	8	9	0	i	71
Myriochele heeri	0	0	0	0	0	0	Ø	9	0	0	9	0	1	9
Galathowenia oculata	9	0	0	0	9	0	0	9	9		9	9	ı	15

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T2-5-A	T2-5-8	T2-5-C	T2-5-D	T2-5-E T2-5	-TOT	73-5-A	13-5-B	T3-5-C	T3-5-0	T3-5-€	T3-5-TOT
Idanthyrsus ornamentatus	0	8	8	0		0	0	9	. 0	0	8	0
Sabellaria cementarium	0	0	1	0		1	8	8	0	9	0	0
Pectinaria sp. Juv	. 0	0	9	0		8	0	. 8	9	0	0	0
Pectinaria californiensis	0	0	0	0		0	8	9	9	0	0	9
Ampharetidae sp. Indet.	1	1	1	0		3	1	0	• 1	1	8	3
Amage anops	9	0	. 0	0		0	8	<b>Q</b>	. 0	0	1	1
Ampharete acutifrons	1	9	9	9		1	0	8		1	2	3
Ampharete firmarchica	0	0	0	1		1	0	0	0	9	8	0
Amphicteis glabra	8	0	8	0		8	9	8	. 8	1	0	1
Melinna elisabethae	8	0	0	•		0	0	0	8	0	0	0
?Sabellides sp.	8	0	1	0		1	9	8	0	9	8	6
Anobothrus gracilis	8	9	0	0		9	0	8	0	4	0	4
Asabellides lineata	0	0	8	9		0	. 0	8	9	0	0	8
Schistocomus hiltoni	0	1	9	0		1	0	8	8	9	3	3
Terebellidae sp. A	0	0	9	0		0	0	0	0	0	0	0
Terebellidae sp. Indet.	9	0	0	9		8	0	1	8	2	1	4
Nicolea zostericola	6	0	0	8		0	8	9	0	6	0	8
Pista sp. Indet.	0	8	0	0		8	8	0	9	0	8	8
Pista cristata	8	0	0	0		9	0	· . •	8	8	0	0
Pista elongata	0	8	8	0		9	8	0	9	8	0	0
Pista brevibranchiata	9	0	0	0		0	0	0	9	3	1	4
Pista moorei	9	0	8	8		0	8	8	0	0	0	0
Polycirrus sp. complex	1	. 0	3	2		6	0	0	0	8	0	8
Thelepus sp. Indet.	0	8	0	0	•	0	0	9	8	0	9	0
Thelepus setosa	0	0	0	8		0	0	8	0	0	0	8
Lanassa venusta venusta	0	0	1	0		1	0	9	9	0	. 0	0
Laphania boecki	0	0	2	0		2	9	0	8	0	0	8
Proclea graffii	0	9	0	0		0	9	0	9		9	0
Scionella japonica	0	0	0	0		0	8	0	0	0	0	
Scionella estevanica	0	9	8	0		9		0	8	9	0	0
Streblosoma bairdi	0	0	0	0		0	. ' @	' 6		0	0	9
Terebellides stroemi	9	0		0		9	8	0	0		8	8
Sabellidae sp. Indet.	1	. 0	9	0		1	2	. 6	2	7	3	14

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asarco stations - Raw Biological Data Taxon Name	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-F	T4-2-TOT	TC 2.0		76.3.0	*C 2 D	7/ 3 5	T/ 3 YOT
IMAUN INDE					T4-2-E		T6-3-A	T6-3-B	T6-3-C	T6-3-D	16-3-E	T6-3-TOT
Idanthyrsus ornamentatus	3	1	8	2	5	11	0	•	0	0	0	0
Sabellaria cementarium	1	5	0	1	1	5	0	8	0	2	0	2
Pectinaria sp. Juv	0	0	8	8	0	8	8	9	1	8	8	1
Pectinaria californiensis	1	9	0	0	0	1	2	8	0	9	9	2
Ampharetidae sp. Indet.	1	1	0	8	1	3	Ģ		9	0	Ø	8
Amage anops	0	9	8	0	8	8	1	9	5	1	0	4
Ampharete acutifrons	6	8	8	8	9	0	8	0	Ģ	0	9	0
Ampharete finmarchica	0	0	9	8	8	8	8	Ô	Ģ	0	0	0
Amphicteis glabra	1	0	0	1	1	3	5	4	1	3	0	10
Melinna elisabethae	8	8	8	8	9	6	8	. 0	0	0	9	0
?Sabellides sp.	. 6	0	8	8	0	0	8	8	0	9	0	0
Anobothrus gracilis	8	0	0	8	6	8	6	3	1	4	5	19
Asabellides lineata	8	0	9	9	. 8	0	0	8	8	Ģ	8	0
Schistocomus hiltoni	0	1	1	0	. 8	2	1	1	6	0	Ó	8
Terebellidae sp. A	8	0	0	8	8	9	. 0	8	9	8	8	9
Terebellidae sp. Indet.	3	5	0	5	5	15	0	.4	5	1	2	9
Nicolea zostericola	9	0	0	0	8	8	Ģ	0	0	0	8	. 8
Pista sp. Indet.	0	0	0	0	0	8	0	8	0	0	6	0
Pista cristata	0	0	8	8	0	6	8	ģ	8	0	9	8
Pista elongata	<b>0</b> ·	8	0	0	9	8	0	8	9	ø	8	9
Pista brevibranchiata	7	2	1	1	0	11	1	1	8	8	8	Ş
Pista moorei	8	0	0	1	8	1	8	0	8	0	0	0
Polycirrus sp. complex	8	2	1	6	1	4	Ġ	Ģ	4	i	8	5
Thelepus sp. Indet.	3	. 8	0	8	9	3	0	0	8	0	8	0
Thelepus setosa	8	0	9	0	1	1	3	i	2	8	0	6
Lanassa venusta venusta	9	. 8	9	9	9	0	Ò	8	0	0	0	0
Laphania boecki	0	0	0	0	8	0	0	0	8	0	0	0
Proclea graffii	0	0	0	4	0	4	8	0	8	0	9	0
Scionella japonica	4	8	1	9	1	6	1	0	2	2	1	6
Scionella estevanica	. 0	0	0	0	0	8	3	3	1	0	0	7
Streblosoma bairdi	0	0	8	1	0	1	0	0	0	8	0	0
Terebellides stroemi	0	0	0	8	9	8	9	9	8	0	0	8
Sabellidae sp. Indet.	1	2	6	3	3	15	1	3	0	4	0	8

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ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T8-4-A	T8-4-B	T8-4-C	T8-4-D	T8-4-E	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
Idanthyrsus ornamentatus	0	0	0	9	0	0	8	0	9	0	8	9
Sabellaria cementarium	1	1	9	0	8	2	0	0	8	0	0	0
Pectinaria sp. Juv	0	6	0	•	0	6	5	7	2	1	4	19
Pectinaria californiensis	2	3	2	i	1	9	6	0	9	1	9	7
Ampharetidae sp. Indet.	0	2	0	8	0	. 2	9	1	. 0	0	0	1
Amage anops	0	0	8	1	1	. 2	9	8	8	8	0	0
Ampharete acutifrons	3	1	0	3	1	8	9	. 9	0	0	9	0
Ampharete finmarchica	0	0	8	0	9	8	1	8	8	0.	0	1
Amphicteis glabra	8	0	1	0	9	1	8	8	0	0	0	0
Melinna elisabethae	0	0	0	0	9	8	0	. 8	0	0	0	9
?Sabellides sp.	0	0	8	` <b>0</b>	0	9	8	8	9	0	9	9
Anobothrus gracilis	1	3	5	8	6	15	0	0	0	0	9	0
Asabellides lineata	0	1	8	8	0	1	0	0	0	0	0	9
Schistocomus hiltoni	8	1	1	9	5	4	0	. 0	8	0	9	0
Terebellidae sp. A	0	8	1	0	0	1	9	0	0	0	9	0
Terebellidae sp. Indet.	2	6	1	6	9	9	1	8	0	0	9	1
Nicolea zostericola	8	0	0	8	1	1	0	8	0	0	0	0
Pista sp. Indet.	8	8	8	0	i	1	8	8	8	8	9	9
Pista cristata	6	0	i	1	0	2	8	0	0	0	0	0
Pista elongata	8	0	0	0	8	8	8	0	8	0	8	0
Pista brevibranchiata	1	1	1	0	0	3	0	8	8	8	8	0
Pista moorei	0	0	0	0	9	0	8	8	8	0	9	9
Polycirrus sp. complex	0	0	3	3	3	9	8	0	0	0	0	0
Thelepus sp. Indet.	8	8	0	8	. 0	8	0	0	. 0	0	9	0
Thelepus setosa	. 0	0	6	0	0	8	0	0	6	0	0	0
Lanassa venusta venusta	8	8	1	0	0	1	9	0	9	8	9	0
Laphania boecki	9	0	0	0	0	0	0	0	9	0	9	8
Proclea graffii	0	.0	8	0	9	0	0	8	0	9	0	. 0
Scionella japonica	0	0	0	0	0	0	1	1	2	1	0	5
Scionella estevanica	0	9	0	8	0	0	0	8	0	0	0	8
Streblosoma bairdi	0	0	0	0	0	8	0	0	9	0	9	0
Terebellides stroemi	1	0	0	8	1	5	0	9	9	. 0	. 6	8
Sabellidae sp. Indet.	0	0	0	3	5	5	9	8	0	8	. 0	0

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ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-E	T11-7-TOT	T12-1-A	712-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-TOT
Idanthyrsus ornamentatus	0	0	0	. 0	0	0	6		0	8	8	8
Sabellaria cementarium	8	i	0		0	1	9	8	. 8	0	9	9
Pectinaria sp. Juv	0	9	0	8	0	0	0	8	0	1	9	i
Pectinaria californiensis	1	ė	. 8	8	0	1	1	9	9	5	8	6
Ampharetidae sp. Indet.	ě	Ö	9	8	8	8	0	6	0	8	8	0
Amage arrops	1	1		0		2	8	9	8	. 8	0	0
Ampharete acutifrons	3	ž	0	1	9	6	6	0	0	8	0	9
Ampharete finmarchica		0			9	0	8		0	0	0	8
Amphicteis glabra	0	9	0	0	0	8	8	8	0	0	0	. 8
Melinna elisabethae	0	9	0		9	9	0	0	0	0	0	9
?Sabellides sp.	0	0	9		9	0	8	0		0	0	
Anobothrus gracilis	1		8		9	1	9	ė	0	8	. 6	0
Asabellides lineata	ō	ě	ě	8	0		8	ē	0	8	0	0
Schistocomus hiltoni	0	9	0	9	9	0	8	0	. 0	8	9	9
Terebellidae sp. A	0	0	0	0	0	8	0.	0	0	ė	0	0
Terebellidae sp. Indet.	0	9	0	9	ø	9	0	8	8	9	8	0
Nicolea zostericola	0	9	0	0	0	9	0	8	8	0	ė	0
Pista sp. Indet.	0	Ò	. 8	8	8	9	8		8	8	8	0
Pista cristata	9	. 0	1	0	•	1	8	8	0	9	0	0
Pista elongata	8	2	0		9	2		8	0	9	9	8
Pista brevibranchiata	9		0	1	, 0	2	9	9	8	0	0	8
Pista acorei	0	0	0	9	8	8	0	0	9	0	0	9
Polycirrus sp. complex	4	4	ž	9	2	21	0	0	0	0	0	8
Thelepus sp. Indet.	0	8	0		9	8	0	0	9	9	9	0
Thelepus setosa	9	0	0	0	0	0	è	ē	8	0	8	8
Lanassa venusta venusta	9	. 0	0	ė	0	0	9	ě	ā	8	9	9
Laphania boecki	9	0	9	0	0	0	9	ē	9	9	0	ā
Proclea graffii	8	9	9	0	2	0	8	ē	â	a		a
Scionella japonica	9	1	8	9	0	1	ā	ē	A	ā	ě	a
Scionella estevanica	1		0	1	. 0	5	9	8	0	9	8	A
Streblosoma bairdi	0	0	0	0	0	8	9	0	<u>a</u>	8	9	a
Terebellides stroemi	8	0	9	Ö	9	0	9	8	ā	8	. 0	A
Sabellidae sp. Indet.	9	8	9	ā	1	i	A	0	1	A	9	1

ASARCO STATIONS - RAW BIOLOGICAL DATA TAXON NAME	T16-1-A	T16-1-B	716-1-C	T16-1-D	T16-1-E	T16-1-TOT	T16-4-A	T16-4-8	T16-4-C	T16-4-D	T16-4-E	T16-4-70T
Idanthyrsus ornamentatus	0	0	8	8	0	. 0	9	8	0	8	0	
Sabellaria cementarium	0	0	9	0	1	1	9	0	0	0	9	0
Pectinaria sp. Juv	0	0	9	9	0	0	8	8	8	0	0	0
Pectinaria californiensis	3	7	4	1	2	17	2	5	3	2	. 5	14
Ampharetidae sp. Indet.	0	8	0	0	8	0		8	8	9	8	<b>Ø</b> -
Amage anops	. 0	0	1	0	0	1	9	0	0	0	8	0
Ampharete acutifrons	0	0	9	6	8	8	8	8	8	8	8	8
Ampharete finmarchica	. 0	0	0	0	8	0	•	0	0	9	0	0
Amphicteis glabra	1	0	1	5	5	9	2	1	: 2	1	2	8
Melinna elisabethae	9	1	1	0	<b>1</b>	3	8	9	9	0	9	9
?Sabellides sp.	8	6	9	•	! 8	8	8	8	8	8	9	9
Anobothrus gracilis	5	5	3	5	1	16	0	9	0	0	9	0
Asabellides lineata	0	₿.	8	0	8	0	8	0	9	0	0	9
Schistocomus hiltoni	0	8	0	0	; 0	0	8	9	. 0	9	9	0
Terebellidae sp. A	8	8	9	8	8	8	8	8	8	8	8	0
Terebellidae sp. Indet.	0	0	8	0	1	1	9	9	8	0	0	8
Nicolea zostericola	8	8	8	8	9		9	0	0	0	9	8
Pista sp. Indet.	8	0	8	9		0	0	9	0	9	9	0
Pista cristata	9	0	9	0	0	9	1	0	9	6	0	1
Pista elongata	0	0	0	0	9	8	9	9	0	8	9	0
Pista brevibranchiata	9	8	8	9	1	1	0	i	0	9	0	1
Pista moorei	8	8	0	0	8	9	8	0	0	0	0	0
Polycirrus sp. complex	3	8	1	0	1	5	1	3	2	0	0	6
Thelepus sp. Indet.	8	0	8	0	0	0	9	8	8	9	9	0
Thelepus setosa	0	9	8	0	0	0	0	8	0	8	0	8
Lanassa venusta venusta	0	0	9	0	0	9	0	0	8	. 0	9	0
Laphania boecki	8	0	8	9	9	9	8	9	0	. 0	8	9
Proclea graffii	9	8	9	1	8	1	1	1	8	8	2	4
Scionella japonica	0	0	0	. 0	0	8	0	0	8	0	9	9
Scionella estevanica	1	1	1	2	2	7	8	8	0	1	0	1
Streblosoma bairdi	0	0	0	9		0,	13-1-10		. 0	. 0	, 0	, , 0
Terebellides stroemi	9	. 0	0	0		9	8	8	0	8	6	8
Sabellidae sp. Indet.	i	2	1	2	9	6	0	2	5	0	3	10

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Scionella estevanica Streblosoma bairdi Terebellides stroemi

Sabellidae sp. Indet.

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ASARCO RAW BIOLOGICAL DATA TAXON NAME	T2-5-A	T2-5-B	T2-5-C	72-5-D	T2-5-E	T2-5-TOT	T3-5-A	T3-5-B	T3-5-C	13-5-D	T3-5-E	T3-5-TOT
Megalomma splendida	6	0	. 0	0		0	0	0	0	1	0	1
Potamilla occelata	0	0	0	9		0	0	0	0	0	' 0	0
Sabella media	0	0	0	9		0	8	0	9	2	8	2
Jasminaria pacifica	1	4	8	9		5	8	0	8	5	5	4
Serpulidae sp. Indet.	0	0	0	0		0	V O	0		v	0 0	e .
Oligochaeta sp. Indet.	0	0	0	0		ъ В	U	y	9	0		
Hirudinea sp. Indet.		0	0	•		0	0	•		0		1
Piscicolidae sp. Indet.	8	9	9	8		9	8	9	<b>v</b>	0	0	т О
Margarites sp. Indet.	9	9	5	6		2	9	0	0		0	0
Bittium sp. Indet.	0	0	0	0		0		0	¥ .	U	0	0
Balcis sp. Indet.	2	0	0	8		2	U	0	9	Ø	_	
Trichotropis cancellata	0	0	0	9		9	0	8	9	8	1	1
Crepipatella lingulata	8	0	0	9		0	0	0	8	U	0	
Velutina velutina	0	0	9	9		0	9	0	9	1	0	1
Ocenebra sp. Indet.	0	0	0	8		0	2	5	3	V	0	10
Alia gausapata	0	1	0	1		2	i	0	0	Ø	0	1
Nassarius mendicus	. 0	0	0	0		9	11	12	6	3	2	34
Olivella baetica	8	1	21	7		37	0	0	8	. 0	8	9
Kurtzia arteaga	•	0	0	9		0	0	0	9	0	6	0
Odostomia (Odostomia) sp. Indet.	,0	0	. 0	0		0	9	0	4	5	0	9
Turbonilla sp. Indet.	0	0	0	8		8	.0	9	0	0	0	8
Odostomia (Chrysallida) sp. Indet.	0	0	0	0		0	9	1	11	6	2	50
Cephalaspidea sp. Indet.	. 0	0	0	0		0	0	0	0	0	0	U
Cylichnella sp. Indet.	0	0	0	0		0	0	. 0	9	0	9	0
Aglaja sp. Indet.	0	9	0	0		0	0	1	8	0	0	1
Gastropteron pacificum	8	8	0	8		8	8	8	8	0	8	8
Nudibranchia sp. Indet.	1	0	0	0		1	0	0	0	0	6	0
Doridacea sp. Indet.	9	9	0	9		9	9	8	9	8	8	8
Doto sp. Indet.	0	0	0	0		0	0	0	0	1	0	1
Aeolidacea sp. Indet.	0	1	0	0		1	8	9	1	1	3	5
Ischnochitonidae sp. Indet.	0	0	0	0		0	.,	. 6	8	0	0	8
Bivalvia sp. Indet.	0	0	9	9		0	0	9	0	0	8	0
Acila castrensis	0	0	0	0		0	0	0	0	0	0	0
Nucula tenuis	0	0	0	9		0	0	0	9	0	0	0
Nuculana minuta	0	0	0	0		0	. 8	9	0	0	. 0	0
Nuculana fossa	6	0	0	9		0	0	9	9	4	0	4
Glycymeris subobsoleta	0	0	0	0	:	0	· 0	0	8	. 0	0	0
Mytilidae sp. Indet.	9	0	9	8		8	. 6	0	8	. 6	0	8
Megacrenella columbiana	. 0	0	9	8		0	, 6	0	9	. 0	. 0	0
Musculus of. olivaceus	0	0	9	0		0	9	9	0	0	0	0

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T4-2-A	T4-2-B	74-2-C	T4-2-D	74-2-€	T4-2-TOT	T6-3-A	T6-3-B	76-3-C	T6-3-D	T6-3-E	T6-3-TOT
Megalomma splendida	0	0	0	0	0	8	0	9	4	8	9	4
Potamilla occelata	0	9	8	0	0	0	1	4	8	1	0	6
Sabella media	6	9	7	9	8	30	8	8	3	2	1	55
Jasminaria pacifica	9	1	0	0	• 1	2	3	1	8	0	0	4
Serpulidae sp. Indet.	8	9	0	0	1	1	8	8	8	0	0	0
Oligochaeta sp. Indet.	0	0	9	8	9	0	8	Ø	0	9	0	0
Hirudinea sp. Indet.	. 8	0	8	9	0	0	0	0	0	9	0	8
Piscicolidae sp. Indet.	7	0	1	2	•	10	8	5	0	2	0	7
Margarites sp. Indet.	9	9	0	0	. 0	0	0	4	5	0	0	9
Bittium sp. Indet.	16	4	5	3	9	34	8	1	2	9	0	3
Balcis sp. Indet.	2	1	0	0	1	4	0	0	0	1	0	1
Trichotropis cancellata	8	8	8	Ģ	ė	8	3	3	5	5	6	19
Crepipatella lingulata	3	3	3	4	2	15	2	3	4	3	0	12
Velutina velutina	0	0	0	0	8	0	0	8	0	1	9	1
Ocenebra sp. Indet.	8	0	0	0	9	0	0	9	1	. 0	0	1
Alia gausapata	. 6	0	0	0	0	0	30	18	26	15	6	95
Nassarius mendicus	1	0	0	9	0	1	0	1	0	0	0	1
Olivella baetica	1	6	8	0	8	1	8	9	0	0	9	8
Kurtzia arteaga	9	0	0	8	0	0	9	1	0	0	6	1
Odostomia (Odostomia) sp. Indet.	-2	1	0	1	1	5	6	9	9	1	0	1
Turbonilla sp. Indet.	0	0	0	0	0	9	0	0	8	8	0	8
Odostomia (Chrysallida) sp. Indet.	0	0	9	8	0	9	8	11	3	23	Ø	37
Cephalaspidea sp. Indet.	8	0	0	0	0	0	0	0	0	9	0	0
Cylichnella sp. Indet.	0	0	Ò	9	9	0	0	8	0	6	0	0
Aglaja sp. Indet.	1	6	1	5	10	23	0	0	8	9	0	0
Gastropteron pacificum	9	1	9	8	8	1	1	0	1	4	9	6
Nudibranchia sp. Indet.	0	8	' 0	0	0	0	9	0	8	0	0	0
Doridacea sp. Indet.	0	0	ð	0	9	0	9	0	9	9	6	ð
Doto sp. Indet.	i	1	0	1	0	3	Ø	0	0	1	0	1
Reolidacea sp. Indet.	1	0	0	0	9	1	ð	0	0	0	0	0
Ischnochitonidae sp. Indet.	0	0	8	0	1	1	9	0	8	0	0	9
Bivalvia sp. Indet.	0	1	1	1	0	3	0	1	, 8	0	0	1
Acila castrensis	0	0	0	0	8	0	0	3	· 0	0	0	3
Nucula tenuis	9	0	0	8	0	0	ð	0	0	0	0	8
Nuculana minuta	. 4	3	0	1	0	7	0	1	0	1	0	5
Nuculana fossa	4	Ø	0	5	5	11	1	6	. 5	7	. 8	16
Glycymeris subobsoleta	9	0	9	9	0	0	8	0	0	0	0	0
Mytilidae sp. Indet.	5	0	9	0	5	4	4	1	0	8	8	13
Megacrenella columbiana	0	0	0	0	0	8	0	0	0	0	8	0
Musculus cf. olivaceus	9	8	Ø	9	0	ď	9	8	8	0	8	0

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T8-4-A	T8-4-B	18-4-C	T8-4-D	T8-4-E	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
Megalomma splendida	0	8	2	.0	2	4	0	0	0	0	0	8
Potamilla occelata	0	0	0	0	. 0	8	9	9	8	0	8	0
Sabella media	. 8	1	4	1	8	6	0	1	0	9	0	1
Jasminaria pacifica	0	9	0	0	0	0	0	9	0	0	0	0
Serpulidae sp. Indet.	0	0	0	9	0	0	0	0	0	0	0	0
Oligochaeta sp. Indet.	9	0	0	8	6	0	20	23	2	1	1	47
Hirudinea sp. Indet.	9	0	0	9	0	. 0	9	0	0	0	0	0
Piscicolidae sp. Indet.	0	8	8	9	0	0	0	9	0	9	1	1
Margarites sp. Indet.	1	0	0	0	0	1	1	1	0	0	0	2
Bittium sp. Indet.	8	8	8	9	8	8	8	8	0	0	0	8
Balcis sp. Indet.	3	8	5	1	2	16	8	0	0	0	0	8
Trichotropis cancellata	1	0	0	. 0	0	1	0	0	8	0	0	8
Crepipatella lingulata	18	17	2	1	. 7	45	0	8	8	8	0	0
Velutina velutina	0	0	8	0	0	0	0	0	0	0	0	0
Ocenebra sp. Indet.	0	0	2	0	8	2	0	8	1 0	0	1	1
Alia gausapata '	8	8	9	1	8	1	9	8	. 0	8	0	0
Nassarius mendicus	0	0	0	8	0	0	₿.	6	8	0	0	0
Olivella baetica	9	6	8	. 1	3	4	0	0	0	0	8	0
Kurtzia arteaga	8	0	0	1	8	1	0	0	0	0	0	0
Odostomia (Odostomia) sp. Indet.	1	0	1	8	8	5	0	9	8	0	9	0
Turbonilla sp. Indet.	1	8	0	8	0	1	0	8	0	0	0	0
Odostomia (Chrysallida) sp. Indet.	0	0	. 0	0	9	0.	1	8	8	0	9	1
Cephalaspidea sp. Indet.	8	0	0	9	8	0	0	0	8	9	0	0
Cylichnella sp. Indet.	8	8	8	8	0	8	8	8	0	. 6	0	8
Aglaja sp. Indet.	2	0	0	8	0	2	8	0	0	8	6	0
Gastropteron pacificum	0	0	0	8	0	0	8	6	0	8	9	8
Nudibranchia sp. Indet.	0	0	0	0	0	0	8	8	8	0	0	. 0
Doridacea sp. Indet.	8	0	i	8	0	1	8	0	9	1	0	1
Doto sp. Indet.	9	0	0	8	0	0	0	0	0	8	. 0	0
Aeolidacea sp. Indet.	0	0	0	9	0	0	8	9	0	0	0	. 9
Ischnochitonidae sp. Indet.	8	8	0	. 0	6	0	8	0	0	8	8	8
Bivalvia sp. Indet.	. 0	0	8	1	8	. 1	9	9	0	0	0	8
Acila castrensis	0	0	0	8	8	9	5	0	. 8	0	• 1	3
Nucula tenuis	0	. 0	0	0	0	0	9	0	0	0	9	8
Nuculana minuta	0	0	8	0	0	0	0	0	0	0	. 0	8
Nuculana fossa	9	2	0	0	1	3	1	1	8	5	9	4
Glycymeris subobsoleta	0	0	0	0	0	0	0	0	0	0	9	0
Mytilidae sp. Indet.	0	8	8	0 :	. 8	. 0	8	8	8	8	. 6	0
Megacrenella columbiana	8	6	4	1	0	19	0	0	8	0	0	0
Musculus cf. olivaceus	0	4	1	2	3	10	8	0	9	. 0	8,	0.

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	711-7-C	T11-7-D	T11-7-E T	11-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-TOT
Megalomma splendida	9	9	0	9	0	0	. 2	0	0	0	0	0
Potamilla occelata	8	ē	9	. 0	Ö	9	0	0	0	9	0	ō
Sabella media	ā	8	0	9	8	. 0	8	0	â	0	. 6	8
Jasminaria pacifica	ā	8	ā	0	. a	0	ō	9	Ö	â	0	ø
Serpulidae sp. Indet.	ā	ø	ā	a	a	Ü	8	9	1 0	Ā	a	A
Oligochaeta sp. Indet.	0	9	Õ	9	ē	0	0	8	. 8	9	8	ě
Hirudinea sp. Indet.	ě	9	0	.6	ē	0	9	0	e	ā	0	20
Piscicolidae sp. Indet.	9	9	8	0	0	9	9	9	9	9	8	0
Margarites sp. Indet.	8	0	0	9	9	0	9	0		9	8	8
Bittium sp. Indet.	9	9	8	e	0	0	9	9	9	8	0	0
Balcis sp. Indet.	2	8	0	8	9	0	9	9	0	0	0	ø
Trichotropis cancellata	8	8	8		0	0	8	0	9	8	8	<b>&amp;</b>
Crepipatella lingulata	0	9	. 8	0	8	0	0	0	9	0	0	0
Velutina velutina	9	0	0	8	9	0	8	9	8	0	0	6
Ocenebra sp. Indet.	0	8	0	9	0	0	0	9	0	0	0	0
Alia gausapata	8	0	8	8	. 0	0	9	9	6	8	0	9
Nassarius mendicus	0	9	0	0	0	0	0	0	1	1	0	2
Olivella baetica	0	8	0	9	9	0	9	9	9	0	9	ø
Kurtzia arteaga	8	0	0	. 9	8	0	0	0	0	8	0	0
Odostomia (Odostomia) sp. Irdet.	0	0	0	0	0	0	8	8	9	0	0	8
Turbonilla sp. Indet.	0	0	0	. 0		0	0	0	0	9	0	0
Odostomia (Chrysallida) sp. Indet.	8	0	. 8	0	9	0	8	0	0	0	0	. 9
Cephalaspidea sp. Indet.	16	8	8	13	20	65	0	0	0	0	8	0
Cylichnella sp. Indet.	9	- 0	1	ė	. 8	1	0	9	ż	8	0	2
Aglaja sp. Indet.	0	0	0	0	. 0	8	0	0	0	0	0	0
Gastropteron pacificum	8	0	0	1	6	1	8	8	8	0	0	0
Nudibranchia sp. Indet.	8	0	0	0	9	0	0	0	8	0	9	0
Doridacea sp. Indet.	9	0	0		. 6	0	0	0	9	0	9	0
Doto sp. Indet.	8	0	0	0	0	0	8	0	0	0	ø	Ø
Aeolidacea sp. Indet.	0	0	0	9	9	0	0	9	0	. 0	0	0
Ischnochitonidae sp. Indet.	0	0	0	9	•	8	0	0	8	0	8	Ø
Bivalvia sp. Indet.	2	4	4	0	4	14	Ø	0	0	0	0	8
Acila castrensis	8	0	0	0	0	Ø	0	0	0	0	0	0
Nucula tenuis	0	9	0	0	8	0	8	0	8	2	0	5
Nuculana minuta	8	0	0	0	0	0	0	0	9	0	0	0
Nuculana fossa	9	0	0	0	0	0	0	Ø	8	0	0	0
Glycymeris subobsoleta	0.	1	0	0	6	i	Ŋ	0	Ø	2	0	2
Mytilidae sp. Indet.	0	0	0	0	0	0	0	0	Ø	0	0	Ø
Megacrenella columbiana	0	Ø	0	. 0	0	, ø	0	0	0	Q	0	0
Musculus cf. olivaceus	0	0	0	V	0	0	9	Ø	8	Ø	0	0

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T16-1-A	T16-1-B	T16-1-C	T16-1-D	T16-1-E	T16-1-TOT	T16-4-A	T16-4-9	T16-4-C	T16-4-D	T16-4-E	T16-4-TOT
Megalomma splendida	0	0	8	0	8	8	9	8	0	8	1	i
Potamilla occelata	8	0	8	9	0	0	8	0	0	9	9	9
Sabella media	0	0	0	8	8	8	0	0	8	8	8	0
Jasminaria pacifica	0	8	0	8	0	0	0	0	9	0	9	0
Serpulidae sp. Indet.	0	0	0	0	6	9	6	6	6	8	8	0
Oligochaeta sp. Indet.	8	0	8	0	0	0	0	9	0	0	9	8
Hirudinea sp. Indet.	8	8	8	8	8	0	8	8	8	8	6	0
Piscicolidae sp. Indet.	8	0	8	9	. 0	0	, 1	. 0	0	9	0	1
Margarites sp. Indet.	2	3	2	5	4	13	<b>'8</b>	8	9	0	0	0
Bittium sp. Indet.	8	9	0	9	0	0	0	0	0	0	0	0
Balcis sp. Indet.	4	2	0	8	0	6	. 0	9	0	0	0	0
Trichotropis cancellata	8	8	8	0	0	9	0	9	9	0	0	0
Crepipatella lingulata	8	. 8	8	8	8	8	0	8	8	8	9	9
Velutina velutina	0	0	8	8	0	9	. 0	9	0	8	8	. 0
Ocenebra sp. Indet.	8	0	8	9	0	8	0	1	9	9	9	1
Alia gausapata	0	0	0	9	0	0	0	0	1	0	9	1 -
Nassarius mendicus	9	0	9	0	8	0	0	2	0	0	0	2
Olivella baetica	9	9	0	0	0	9	9	0	0	0	0	8
Kurtzia arteaga	0	9	0	9	9	9	9	8	9	9	0	8
Odostomia (Odostomia) sp. Indet.	9	0	5	5	5	9	9	0	9	9	0	0
Turbonilla sp. Indet.	1	0	8	0	0	1	0	9	8	9	9	8
Odostomia (Chrysallida) sp. Indet.	0	0	11	9	9	11	0	0	0	0	9	0
Cephalaspidea sp. Indet.	0	. 0	8	9	0	0	9	0	9	8	0	0
Cylichnella sp. Indet.	8	9	9	8	9	8	9	9	•	9	9	9
Aglaja sp. Indet.	9	0	0	9	9	8	. 0	1	0	0	6	1
Gastropteron pacificum	3	8	9	5	8	5	8	1	8	9	9	1
Nudibranchia sp. Indet.	0	8	0	0	9	6	8	8	0	0	9	0
Doridacea sp. Indet.	8	8	8	9	ė	0	9		9	6	9	9
Doto sp. Indet.	. 0	9	ā	0	9	0	9	8	8	0	0	0
Aeolidacea sp. Indet.	ā	9	5	9	1	3	8	8	0	8	8	9
Ischnochitonidae sp. Indet.	a	2	1	2	1	6	ø	0	9	8	9	0
Bivalvia sp. Indet.	7	16	1	4	21	49	Ā	4		è	8	4
Acila castrensis	, a	a		Å	,	. 0	· ä	11 6	i a	;; 'A	' A	
Nucula tenuis	· a	1	ā	A	a	1	a	ā	ñ	Ã	a	ø.
Nuculana minuta	a	a	0	a	a	0	a a	a	a	Ä	a	Ä
Nuculana fossa	a	Q	9	a	0	0	Ď,	1	2	<u>ل</u>	1	12
Glycymeris subobsoleta	0	. 0	20	9	a	0	7	•	a	1	i	
		2	5	5	(	10		•	0			- 7
Mytilidae sp. Indet.	4	0	0	9	0		. 0	1	0	φ	. 8	•
Megacrenella columbiana	8	e 0	9	9	v 0		8	0	8	0	. 0	<u>a</u>
Musculus of. olivaceus	Ø	U	¥	v	Ø	Ø	Ø	v		Ø	U	U

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ASARCO RAW BIOLOGICAL DATA TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-T0T	T22-2-A	T22-2-B	722-2-C	T22-2-D	T22-2-E	T22-2-TDT		GRAND TOTAL
'Megalomma splendida	9		0	8	8	0	e		0	0	8	0	1	10
Potawilla occelata	9		1	8	. 0	1	0	0	9	9	0	ē		7
Sabella media	0	0	2	9	9	5	0	1	0	0	0		1	64
Jasminaria pacifica	8	9	0	9	8	0	8	9	9	8	8	ė		15
Serpulidae sp. Indet.	0	0	9	0	0	0	0	9	8	8	8	0		1
Oligochaeta sp. Indet.	17	18	48	- 5	29	198	2	8	12	ā	4	28		183
Hirudinea sp. Indet.	8	0	0	0	0	0	8	0	0	0	0	0	ı	1
Piscicolidae sp. Indet.	0	0	0	0	8	0	0	0	9	9	0	0	i	19
Margarites sp. Indet.	9	0	8	9	0	. 0	i	1	0	0	4	6	ł	33
Bittium sp. Indet.	0	. 0	8	0	0	0	0	0	0	0	1	1	1	38
Balcis sp. Indet.	9	8	0	8	8	0	0	0	0	0	0	. 0	1	29
Trichotropis cancellata	0	0	0	9	8	8	0	0	0	8	0	9	ı	21
Crepipatella lingulata	1	1	0	0	8	2	0	8	9	1	8	i	1	75
Velutina velutina	9	0	9	9	8	8	3	6	9	9	4	31	ı	<b>3</b> 3
Ocenebra sp. Indet.	0	0	8	8	0	8	8	0	0	8	8	0	1	15
Alia gausapata	8	0	0	9	0	. 8	9	16	0	13	8	37	1	137
Nassarius mendicus	9	0	0	8	9	0	0	9	0	0	0	0	ı	40
Olivella baetica	0	0	0	Ð	8	9	Ø	0	0	8	0	0	1	42
Kurtzia arteaga		0	0	8	9	8	0	8	0	8	0	0	1	2
Odostomia (Odostomia) sp. Indet.	0	0	9	0	0	0	0	0	9	0	0	0	1	26
Turbonilla sp. Indet.	1	0	8	9	0	1	0	0	8	8	0	9	1	3
Odostomia (Chrysallida) sp. Indet.	0	0	0	8	0	0	0	0	0	9	0	0	.1	69
Cephalaspidea sp. Indet.	9	0	0	0	9	0	. 0	0	0	6	9	0	j	65
Cylichnella sp. Indet.	. 0	0	1	1	8	2	0	9	0	8	8	9	1	5
Aglaja sp. Indet.	0	9	0	0	. 8	0	0	0	9	0	9	0	1	27
Gastropteron pacificum	0	. 0	9	0	0	0	0	0	9	8	9	0	1	14
Nudibranchia sp. Indet.	. 8	0	8	0	8	8	1		1	8	8	2	ļ	3
Doridacea sp. Indet.	8	0	1	1	1	3	9	0	9	9	0	9	i	5
Doto sp. Indet.	8	9	0	0	0	0	ø	0	0	0	0	0	1	5
Aeolidacea sp. Indet.	1	3	8	12	6	30	0	0	ø	9	0	0	1	40
Ischnochitonidae sp. Indet.	0	0	9	0	0	6	0	8	0	0	Ø	8	ı	7
Bivalvia sp. Indet.	4	2	1	3	4	14	0	0	0	0	1	1	ì	87
Acila castrensis	0	0	0	0	0	0	Ø	0	0	0	8	0	ı	6
Nucula tenuis	0	9	8	0	0	0	0	0	6	0	0	0	ł	3
Nuculana minuta	Ø	0	0	0	0	0	9	9	0	9	0	0	1	9
Nuculana fossa	0	8	Ò	0	0	0	0	0	9	1	0	1	ı	51
· Glycymeris subobsoleta	, 3	3	1	0	3	10	0	0	0	0	6	0	I	17
Mytilidae sp. Indet.	0	0	0	0	0	. 0	0	0	0	0	0	0	t	28
Megacrenella columbiana	8	0	1	1	0	2	1	0	0	0	0	1	.1	55
Musculus of. olivaceus	0	0	1	0	Ø	1	Ø	Ø	0	1	0	1	ł	12

ASARCO RAW BIOLOGICAL DATA											•
taxon name	T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-E T2-5-TOT	T3-5-A	T3-5-B	†3-5-€	T3-5-D	13-5-E	T3-5-TOT
Modiolus rectus	9	0	1	9	1	0	0	0	0	9	0
Chlamys sp. Indet.	9	0	0	0	9	9	0	8	0	0	0
Delectopecten sp. Indet.	0	0	9	0	8	0	8	9	0	8	0
Pododesmus macrochisma	0	9	0	0	0	0	8	0	0	8	0
Lucinoma acutilineata	6	0	0	0	0	0	0	0	0	0	0
Adontorhina cyclia	0	0	8	0	0	0	8	0	9	0	0
Axinopsida serricata	0	8	9	0	0	0	0	9	0	1	1
Mysella tumida	0	0	0	0	0	8	0	9	6	0	. 0
Parvilucina tenuisculpta	9	0	0	0	0	0	0	9	0	0	0
Astarte alaskensis	8	0	0	8	0	9	, 0	9	8	0	0
Clinocardium sp. Indet.	8	0	0	8	9	0	0	9	9	0	0
Serripes groenlandicus	8	0	8	9	8	6	8	0	0	1	1
Nemocardium centifilosum	8	0	1	8	1	0	8	. 6	0	0	
Solen sicarius	8	0	0	0	8	0	8	9	9	8	0
Macoma sp. Indet.	8	0	0	8	9	2	0	5	3	0	10
Macoma elimata	8	8.	8	8	8	8	8	8	8	8	8
Macoma obliqua	0	0	0	8	8	0	0	0	0	8	0
Macoma cf. moesta alaskana	8	0	0	0	0	9	8	9	0	8	0
Macoma yoldifomis	9	8	8	8	9	9	1	9	i	9	2
Macoma carlottensis	0	0	8	0	0	9	0	0	2	8	5
Tellina nuculoides	0	0	0	1	1	0	0	0	0	9	0
Semele rubropincta	0	0	0	9	0	0	0	6	0	0	9
Compsomyax subdiaphana	0	0	0	9	0	0	0	0	8	8	0
Psephidia lordi	0	0	0	0	0	0	0	9	0	0	0
Mya arenaria	0	0	0	0	0	0	6	0	0	0	8
Hiatella arctica	5	5	5	0	9	0	0	0	0	9	0
Bankia setacea	0	Ø	0	0	9	0	0	9	8	0	0
Pandora filosa	0	0	0	8	0	0	0	0	9	0	9
Lyonsia arenosa	0	0	0	8	0	0	0	0	0	0	0
Cardiomya californica	0	0	9	0	0	0	8	9	0	0	. 0
Arachnida sp. Indet.	9	0	0	0	0	0	8	0	0	0	0
Halacaridae sp. Indet.	0	0	0	0	9	. 6	0	3	, 0	0	3
Pycnogonida sp. Indet.	8	0	0	0	0	. 0	. 0	0	0	8	0
Crustacea sp. Indet.	0	9	0	8	0	0	0	0	0	0	0
Ostracoda sp. Indet.	0	0	0	0	0	0	0	0	0	0	8
Cylindroleberidinae sp. Indet.	0	0	6	0	6	•	8	0	0	0	9
Rutiderma lomae	0	0	0	0	0	1	0	1	1	0	3
Euphilomedes carcharodonta	0	0	0	. 0	0	9	8	1	0	0	1
Euphilomedes producta	0	0	8	0	0	8	8	9	9	9	. 8
Calancida sp. Indet.	0	0	0	0	0	1	0	0	.0	. 8	i

ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-B	T6-3-C	T6-3-D	T6-3-€	T6-3-TOT
Modiolus rectus	59	93	88	80	74	394	0	8	0	1	0	1
Chlamys sp. Indet.	5	8	1	Ş	1	6		8	. 8.	8	0	9
Delectopecten sp. Indet.	0	8	0	0	9	0	5	6	12	3	8	26
Pododesmus macrochisma	9	0	6	0	0	9	8	0	8	0	9	0
Lucinoma acutilineata	0	9	8	8	0	0	8	8	6	9	0	8
Adontorhina cyclia	9	0	. 0	0	0	9	9	0	9 .	0	0	8
Axinopsida serricata	1	. 8	0	1	1	3	8	1	8 '	9	. 0	1
Mysella tumida	8	Ģ	0	0	0	6	0	0	0	0	0	9
Parvilucina tenuisculpta	1	1	8	8	0	2	0	9	8	0	0	8
Astarte alaskensis	0	8	8	8	8	9	0	0	8	8	0	8
Clinocardium sp. Indet.	8	0	0	0	2	2	0	8	8	9	9	9
Serripes groenlandicus	9	0.	8	8	8	9	8	9	ė	8	0	8
Nemocardium centifilosum	9	0	0	0	0	0	2	0	1	0	8	3
Solen sicarius	0	1	8	è	9	1	0	8	8 -	8	8	0
Macoma sp. Indet.	1	8	0	0	9	1	0	0	8	8	0	0
Macoma elimata	8	0	8	0	9	0	8 .	8	8	0	8	8
Macoma obliqua	8	0	0	8	9	0	0	0	0 -	0 .	0	. 8
Macoma cf. moesta alaskana	3	8	8	2	0	5	8	8	8	6	0	. 0
Macoma yoldifomis	9	8	8	1	0	1	0	8	0	0	8	. 0
Macowa carlottensis	0	1	3	2 .	0	6	8	0	9	1	8	1 1
Tellina nuculoides	. 2	0	0	<b>.</b>	0	2	8	3	5 %	9	4	21 1
Semele rubropincta	•	0	8	8	0	. 6	4	8	21	13	9	46
Compsomyax subdiaphana	0 .	9	0	8	0	0	1 :	2	0	1	0	4
Psephidia lordi	, 8	1	9	0	Ø	1	9	8	0	8 .	0	. 8
Mya arenaria	9	0	8	1	0	1	0	9	8	8	0	0
Hiatella arctica	19	9	18	9	0	28	6	1	1	1	0	3
Bankia setacea	0	0	0	9	0	0	0	15	0	3	9	18
Pandora filosa	. 6	. 0	8	8 .	0	0	6	12	12	19		. 49
Lyonsia arenosa	9	0	9	0	0	0	2	16	7	0	9	25
Cardiomya californica	0	0	8	0	0	0	0	4	5	8	9	6
Arachnida sp. Indet.	0.,	0	8	9	9	0	0	0	8	0	. 0	8
Halacaridae sp. Indet.	0	•	0	4	9	4	9	0	8	0	0	8
Pycnogonida sp. Indet.	0	9	0	0		0	0	0	22	0	0	22
Crustacea sp. Indet.	8	8	8	8	0	0	0	0	0	9	8	8
Ostracoda sp. Indet.	9	0	0	8	0	0	0	8	8	0	8	0
Cylindroleberidinae sp. Indet.	9	0	8	0	9	0	0	8	0 .	8	0	0
Rutiderma lomae	8	3	3	3	8	25	0	1	Ģ	0	0	. 1
Euphilomedes carcharodonta	0	0	9	0	0	0	0	1	9	0	9	1
Euphilomedes producta	1	0	0	0	0	1	0	0	0	0	0	0
Calanoida sp. Indet.	0	9	9	0	0	Ø	0	8	0	9	0	0

Taxon name	T8-4-A	T8-4-B	T8-4-C	T8-4-D	T8-4-E	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
Modiolus rectus	3	4	3	3	3	16	1	1	9	1	0	3
Chlamys sp. Indet.	8	9	0	9	1	1	Ø	9	0	8	. 8	. 0
Delectopecten sp. Indet.	0	0	2	0	0	5	0	0	0	0	0	0
Pododesmus macrochisma	9	0	0	0	0	0	0	8	8	9	9	0
Lucinoma acutilineata	8	0	0	0	0	0	0	0	0	0	9	9
Adontorhina cyclia	9	0	0	9	0	0	. 0	9	0	0	9	0
Axinopsida serricata	0	8	0	3	0	3	0	0	8	0	0	_
Mysella tumida	0	9	0	0	9	0	9	8	0	0	8	
Parvilucina tenuisculpta	1	8	2	8	9	3	8	9	8	9	6	9
Astarte alaskensis	0	0	0 .	8	0	0	0	0	0	0	9	8
Clinocardium sp. Indet.	0	0	0	0	0	0	8	2	8	0	0	2
Serripes groenlandicus	0	0	5	9	0	5	1	9	8	5	0	3
Nemocardium centifilosum	4	9	9	2	11	35	1	9	9	9	9	
Solen sicarius	0	8	0	0	8	0	0	0	8	9	0	_
Macoma sp. Indet.	0	0	0	0	8	0	0	0	0	. 0	0	-
Macoma elimata	1	5	. 8	8	3	6	2	6	8	5	9	-
Macoma obliqua	2	0	8	. 0	3	5	0	0	0	0	0	0
Macoma cf. moesta alaskana	0	0	5	5	0	18	•	0	0	0	0	0
Macoma yoldifomis	0	3	1	8	2	6	0	9	0	0	0	8
Macoma carlottensis	0	0	8	0	7	7	0	0	0	0	9	8
Tellina nuculoides	9	8	0	0	8	0	0	8	0	0	0	0
Semele rubropincta	0	0	0	0	0	0	2	6	3	7	1	19
Compsomyax subdiaphana	9	9	0	8	8	0	9	1	9	8	9	i
Psephidia lordi	0	0	0	8		0	1	1 1	9	1	· 1	4
Mya arenaria	. 4	1	3	4	7	19	8	0	•	9	0	0
Hiatella arctica	1	4	5	2	3	12	8	9	8	8	8	0
Bankia setacea	9	0	0	9	8	0	8	0	8	0	8	0
Pandora filosa	0	0	0	9	9	0	8	0	9	8	1	1
Lyonsia arenosa	2	8	0	8	15	33	0	0	2	0	0	2
Cardiomya californica	0	0	0	0	0	0	0	9	0	Ø	0	0
Arachnida sp. Indet.	. 1	9	9	0	3	4	0	0	9	0	0	0
Halacaridae sp. Indet.	8	9	9	9	1	ì	9	0	0	8	0	8
Pycnogonida sp. Indet.	0	i	1	5	2	6	Õ	ã	Ó	0	9	
Crustacea sp. Indet.	ā		ė	8	a	9	. 0	9	0	9	0	
Ostracoda sp. Indet.	ø	Q.	0	9	a	9		ñ	0	9	0	
Cylindroleberidinae sp. Indet.	b 0	9	9	9	a	0	Ø	a	0	n	0	
Rutiderma lomae	8	0	9	1	1	5	a	0	a	A	. 0	
unringling inner	v	Æ.	U	1		٤		U	-		-	

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Euphilomedes carcharodonta Euphilomedes producta

Calanoida sp. Indet.

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	711-7-C	711-7-D	711-7-E	T11-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-0	T12-1-E	T12-1-TOT
Modiolus rectus	9	0	<u>.</u>	0	8	·	0	0	6		a	a
Chlamys sp. Indet.	8	8	9	9	0	ē	9	9		a	8	a
Delectopecten sp. Indet.	8	0	0	8	8	0	9	0	9	9	0	a
Pododesmus macrochisma	8	0	9	0	0	0	9	0	8	. 0	8	ě
Lucinoma acutilineata	0	0	0	9	0	0	0	0	8	. 0	ø	0
Adontorhina cyclia	3	0	. 3	0	1	7	0	8	9	. 8	0	9
Axinopsida serricata	8	0	9	. 0	0	9	0	0	9	. 0	8	8
Mysella tumida	0	9	0	9	0	8	0	0	ē	0	0	Ö
Parvilucina tenuisculpta	1	0	1	0	9	2	0	0	0	0	8	9
Astarte alaskensis	9	0	9	0	0	0	0	0	0		9	9
Clinocardium sp. Indet.	0	. 0	0	0	9	9	0	9	ā	a	0	a
Serripes groenlandicus	0	9	0	9	9	0	a	ě	ā	ě	a	a
Nemocardium centifilosum	0	9	9	9	e e	9	0	9	ā	R	8	ä
Solen sicarius	9	9	9	0	. 0	9	0	1 0	ē	a	8	_
Macoma sp. Indet.	0	9	8	0	0	0	ø	9	8	9	0	-
Macoma elimata	9	6	0	9	0	8	ē	0	ē	1	9	1
Macoma obliqua	8	0	8	8	8	2	8	0	1	2	8	3
Macoma cf. moesta alaskana	0	0		9	0	0	0	8	9	9	0	9
Macoma yoldifomis	8	0	0	8	0	2	2	9	A	a	9	9
Macoma carlottensis	ē	9	ā		ā	A	a	8	e	a	9	ā
Tellina nuculoides	ē	A	ā	8	ā	a	a	Q	a	A	ā	•
Semele rubropincta	9	a	a	9	0	ě	a	Q	A	ā	ē	ā
Compsomyax subdiaphana	a	a	8	9	a	a	ā	a	Ā	a	ā	a
Psephidia lordi	9	0	8	0	2	18	0	9	ä	0	9	ě
Mya arenaria	ā	8	8	8	9	ā	ě	9	0	a	8	0
Hiatella arctica	8	9	. 0		ä	ø	8	0	ā	. 0	9	9
Bankia setacea	0	Õ	a	8	8	ø	0	0	9	0	9	. 0
Pandora filosa	9	9	9	9	0	0	0	8	9	Õ	0	. 0
Lyonsia arenosa	9	2	0	8	0	2	0	0	8	0	0	. 0
Cardiomya californica	0	9	9	9	9	0	Ø	9	8	0	0	. 0
Arachnida sp. Indet.	0	0	0.		8	0	0	8	0	0	0	. 0
Halacaridae sp. Indet.	0	8	. 0	9	. 1	1	0	ø	8	6	8	. 0
Pycnogonida sp. Indet.	1	0	8	8	0	1	0	0	0	0	0	. 0
Crustacea sp. Indet.	9	9	9	9	9	. 0	8	9	8	0	0	. 0
Ostracoda sp. Indet.	9	0	0	9	a	ø	0	0	9	0	8	. 0
Cylindroleberidinae sp. Indet.	0	0	ð	ě	0	•	9	2	a	a	ě	, iA
Rutiderma lomae	a	0	ě	ē	9	=	0	8	a	Ã	8	, a
Euphilomedes carcharodonta	2	ø	ø	0	. 0	_	ě	9	a	1	0	•
Euphilomedes producta	0	0	Ø	9	0	-	9	0	A	a	a	, a
Calanoida sp. Indet.	0	0	9	0	0		9	9	ø	0	1	1

ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T16-1-A	T16-1-B	T16-1-C	T16-1-D	T16-1-€	T16-1-TOT	T16-4-A	T16-4-B	716-4 <b>-</b> C	T16-4-D	T16-4-E	T16-4-TOT
Modiolus rectus	9	0	9	8	8	 0	8	0	8	0	0	9
Chlamys sp. Indet.	9	8		. 6	. 0	9	9	Ö	9	9	i	i
Delectopecten sp. Indet.	0	0	0	0	0	9	0	0	9	8	0	0
Pododesmus macrochisma	0	0	0	0	0	9	0	0	0	8	9	0
Lucinoma acutilineata	0	0	0	8	9	9	0	0	8	0	9	0
Adontorhina cyclia	8	2	5	2	5	8	0	9	8	0	0	8
Axinopsida serricata	7	2	1	2	0	12	0	0	0	. 0	0	0
Mysella tumida	0	0	0	8	0	0	9	8	0	9	6	0
Parvilucina tenuisculpta	0	0	0	0	0	0	0	9	0	0	0	9
Astarte alaskensis	9	0	8	9	0	9	9	9	8	0	9	9
Clinocardium sp. Indet.	0	0	0	9	8	0	13	2	1	15	11	42
Serripes groenlandicus	. 0	8	8	0	0	0	6	9	0	0	0	0
Nemocardium centifilosum	1	0	0	0	1	2	9	0	9	0	9	9
Solen sicarius	0	0	0	9	0	0	0	9	8	8	0	9
Macoma sp. Indet.	8	0	0	0	9	0	8	0	8	0	0	9
Macoma elimata	8	8	9	0	8	8	0	8	8	8	8	0
Macoma obliqua	8	0	0	0	0	0	0	2	9	0	8	2
Macoma cf. moesta alaskana	2	5	3	0	8	10	0	5	0	0	8	5
Macoma yoldifomis	, <b>8</b>	9	8	8	8	8	8	8	8	8	0	0
Macoma carlottensis	0	8	9	8	0	0	8	9	0	9	0	0
Tellina nuculoides	0	9	0	8	0	0	0	0	0	9	0	0
Semele rubropincta	•	8	9	8	8	8	0	1	9	•	9	1
Compsomyax subdiaphana		0	. 8	6	0	0	2	5	6	9	2	15
Psephidia lordi	0	9	0	0	0	. 0	0	1	0	0	0	1
Mya arenaria	0	0	0	6	9	9	1	. 3	ı	0	. 0	- 5
Hiatella arctica	9	9	0	9	8	0	1	1	0	0	. 0	2
Bankia setacea	0	0	0	0	0	0	0	0	8	9	0	8
Pandora filosa	11	1	10	3	5	30	2	0	0	0	0	2
Lyonsia arenosa	0	8	9	8	0	0	3	3	2	1	3	12
Cardiomya californica	0	0	0	9	Ø	0	0	9	9	9	0	0
Arachnida sp. Indet.	Ġ	0	0	0	0	0	8	9	0	0	0	9
Halacaridae sp. Indet.	0	0	0		0	•	9	. 0	\ 0	0	0	8
Pycnogonida sp. Indet.	9	0	9	Ġ	1	i	0	0	0		. 0	0
Crustacea sp. Indet.	8	0	0	0	0	0	0	8	0	0	0	0
Ostracoda sp. Indet.	0	9	0	0	0	6	ø	ė	0	0	0	0
Cylindroleberidinae sp. Indet.	0	0	0	0	0	0	Ó	1	9	9	1	5
Rutiderma lomae	0	8	0	0	0	9	0	0	1	0	0	· 1
Euphilomedes carcharodonta	98	64	54	70	109	395	0	9	3	0	1	4
Euphilomedes producta	1	0	1	3	3	8	7.	4	3	12	5	31
Calanoida sp. Indet.	0	0	0	0	0	0	ė	0	0	0	0	0

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-TOT	T22-2-A	T22-2-B	T22-2-C	T22-2-D	T22-2-E	T22-2-T0T		grand Total
Modiolus rectus	0	0	0	Ø	0	0	55	9	13	10	17	71	1	486
Chlamys sp. Indet.	. 8	0	0	0	9	0	0	0	Ø	0	0	0	ı	8
Delectopecten sp. Indet.	0	0	0	0	8	6	8	9	9	6	0	0	1	28
Pododesmus macrochisma	9	0	0	1	0	. 1	0	0	0	8	0	_	1	1
Lucinoma acutilineata	2	9	0	2	1	5	6	8	3	5	15	37	ł	42
Adontorhina cyclia	0	9	0	8	. 0	0	0	0	8	0	8	-	1	15
Axinopsida serricata	8	8	0	0	0	9	ð	0	9	8	5	5	ł	22
Mysella tumida	5	10	3	5	5	28	0	Ø	0	8	0	8	1	28
Parvilucina tenuisculpta	. 6	4	3	4	4	21	8	1	0	0	2	3	1	31
Astarte alaskensis	8	8	6	0	1	23	1	0	0	i	0	2	1	25
Clinocardium sp. Indet.	0	0	0	0	0	9	0	9	9	0	9	0	1	46
Serripes groenlandicus	. 0	9	0	0	8	8	0	8	8	0	. 8	8	i	6
Nemocardium centifilosum	. 0	9	0	. 8	0	8	0	0	0	8	8	0	1	42
Solen sicarius	0	0	0	8	8	. 0	2	0	3	0	2	7	1	8
Macowa sp. Indet.	9	9	8	0	0	8	0	0	0	8	0	9	1	11
Macoma elimata	8	0	0	0	0	9	0	9	9	0	9	0	1	11
Macoma obliqua	3	. 0	0	8	8	3	9	Ø	0	8	0	0	1	13
Macoma cf. moesta alaskana	9	9	1	0	. 0	1	0	8	0	9	8	0	1	31
Macoma yoldifomis	9	. 8	0	0	8	8	0	0	0	0	0	8	ł	9
Macoma carlottensis	. 11	33	22	12	18	88	0	0	0	0	0	0	1	104
Tellina nuculoides	9	9	0	0	8	9	0	1	1	0	2	4	ı	28
Semele rubropincta	0	0	1	0	0	1	0	9	. 8	0	1 0	0	ļ	67
Compsomyax subdiaphana	0	0	9	8	0	0	8	Ø	0	0	9	0	ł	20
Psephidia lordi		9	0	1	0	1	8	0	0	0	0	9	1	7
Mya arenaria	0	0	9	9	0	0	0	1	9	0	. 0	1	ı	26
Hiatella arctica	0	0	1	0	8	1	0	0	0	0	. 6	0	ļ	55
Bankia setacea	1	9	9	0	1	2	0	Ø	0	b	0	0	j	20
Pandora filosa	10	11	8	6	5	40	0	0	0	0	0	9	1	122
Lyonsia arenosa	0	0	9	0	0	Ø	0	0	0	9	0	0	ı	74
Cardiomya californica	8	0	9	0	9	0	24	11	15	1	3	54	1	60
Arachnida sp. Indet.	0	9	0	1	0	1	0	0	0	8	0	0	ı	5
Halacaridae sp. Indet.		0	0	0	9	0	0	0	1	0	1	2	ł	11
Pycnogonida sp. Indet.	8	0	. 0	9	2	5	0	0	9	0	0	. 6	i	32
Crustacea sp. Indet.	0	9	0	0	0	8	0	1	0	0	0	1	ļ	1
Ostracoda sp. Indet.	1	0	Ø	1	0	5	9	Ø	0	8	0	0	ļ	2
Cylindroleberidinae sp. Indet.	ē	0	0		9	9	3	2	2	9	0		ł	9
Rutiderma lomae	0	9	5	ø	0	5	2	3	2	1	0		i	42
Euphilomedes carcharodonta	270	343	86	51	67	817	283	216	138	140	140	917	ì	2241
Euphilomedes producta	15	В	3	10	12	48	105	55	44	44	61	309	i	397
Calaroida sp. Indet.	0	9	ē	ø	8	0	0	0	0	0	0	0	1.	2

ASARCO RAW BIOLOGICAL DATA	•						,				
taxon name	T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-E T2-5-TOT	T3-5-A	T3-5-B	T3-5-C	T3-5-D	13-5-E	T3-5-TOT
Calanus pacificus	0	 0			0	0	8	1	0	8	1
Paracalanus sp. Indet.	0	9	0	8	. 0	8	0	8	0	8	0
Aetideidae sp. Indet.	0	8	0	8	9	0	8	9	0	0	0
Harpacticoida sp. Indet.	0	9	0	0	0	0	0	. 0	8	9	8
Harpacticus uniremis	0	0	. 0	0	0	0	0	0	0	0	0
Peltidiidae sp. Indet.	0	8	9	. 0	0	8	0	0	0	0	0
Typhlampiascus sp. Indet.	0	0	0	0	0	0	0	8	0	0	9
Rhynchothalestris helgolandica	0	0	9	0	0	0	8	0	0	0	0
Cirripedia sp. Indet.	0	0	0	8	9	0	0	0	0	0	0
Scalpellum columbianum	0	0	0	9	. 0	0	0	9	0	9	8
Balanus sp. Indet. (juvenile)	8	0	0	0	0	0	8	1	1	1	3
Balanus crenatus	0	0	0	. 0	0	0	. 0	0	0	8	0
Nebalia pugettensis	0	0	0	0	0	0	0	0	0	0	8
Cumacea sp. Indet.	0	0	0	8	0	0	0	0	0	0	0
Lampropidae sp. Indet.	0	9	0	0	0	8	9	9	0	0	0
Lamprops quadriplicata	0	0	0	0	0	8	8	0	0	9	0
Eudorella pacifica	8	8	0	9	0	0	0	8	1	0	1
Eudorellopsis longirostris	9	0	9	0	0	0	9	8	0	9	8
Diastylis sp. B	8	0	0	0	. 0	0	0	0	0	0	0
Diastylis paraspinulosa	9	0	0	. 0	8	9	8	0	8	9	0
Leptostylis sp. Indet.	•	0	0	9	0	8	0	1	0	0	1
Leptostylis villosa	9	0	6	0	0	0	0	9	0	9	0
Compylaspis hartae	0	9	0	0	0	0	0	0	1	8	1
Campylaspis nodulosa	0	0	9	8	8	9	8	8	0	. 0	8
Cumella sp. Indet.	0	0	0	8	0	0	0	0	8	0	0
Tanaid sp. Indet.	9	8	0	0	0	9	8	0	0	0	0
Zeuxo normani	8	8	0	0	0	0	8	8	0	6	8
Leptochelia savignyi	0	0	0	0	0	2	8	0	0	0	2
Leptochelia dubia	0	0	0	0	0	0	0	8	. 0	0	8
· Leptognathia gracilis	0	1	8	0	1	1	0	1	2	2	6
Haliophasma geminata	9	0	0	0	8	0	0	0	0	0	0
Limnoria lignorum	8	8	8	•	8	0	8	0	0	8	. 8
Synidotea sp. Indet. (juvenile)	0	0	0	0	8	0	8	0	0	0	0
Synidotea angulata	0	0	0	1	1	0	8	0	0	0	0
Munna sp. Indet.	0	9	0	0	0	0	0	0	0	0 -	0
Pleurogonium rubicundum	0.	0	0	2	5	0	9	0	8	0	0
Munnogonium tillerae	0	0	0	0	0	9	0	0	0	8	9
Amphipoda sp. Indet.	0	6	0	0		9	0	0	0	8	8
Gamaridea sp. Indet.	ē	ō	ē	0	0	0	1	· 1	0	ø	2
Ampelisca agassizi	20	7	10	9	37	0	9	3	5	0	8
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ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-B	T6-3-C	16-3-D	T6-3 <b>-</b> €	T6-3-TOT
Calanus pacificus	9	0	1	0	ė	1	9	0	0	1	0	1
Paracalanus sp. Indet.	0	0	0	0	8	0	0	0	8	0	8	0
Aetideidae sp. Indet.	8	0	8	0	0	0	0	0	0	0	0	8
Harpacticoida sp. Indet.	8	. 0	2	8	9	5	8	8	₽ .	8	0	9
Harpacticus uniremis	0	0	9	0	9	8	0	8	8	. 0	0	0
Peltidiidae sp. Indet.	0	8	9	0	Ø	6	8	9	0	8	9	9
Typhlampiascus sp. Indet.	8	8	0	8	8	0	0	8	0	0	8	9
Rhynchothalestris helgolandica	0	0	. 0	9	9	0	8	8	0	0	0	0
Cirripedia sp. Indet.	0	9	9	8	9	0	8	1	0	0	. 0	i
Scalpellum columbianum	6	9	0	2	2	10	0	3	0	1	9	4
Balanus sp. Indet. (juvenile)	5	1	7	4	2	19	0	8	0	1	0	1
Balanus crenatus	28	9	0	5	4	34	8	0	8	0	8	9
Nebalia pugettensis	1	. 0	8	1	9	2	0	0	8	é	8	8
Cumacea sp. Indet.	9	9	9	0	<u>0</u>	0	0	9	0	0	8	0
Lampropidae sp. Indet.	0	8	9	9	0	0	0	8	0	0	9	Ģ
Lamprops quadriplicata	8	0	8	9	8	0	0	0	Ò	Ģ	0	8
Eudorella pacifica	1	0	8	8	0	1	7	2	6	2	0	17
Eudorellopsis longirostris	8	0	9	0	0	0	0	9	9	9	0	. 6
Diastylis sp. B	8	0	0	9	0	8	0	8	0	. 0	9	0
Diastylis paraspinulosa	9	0	0	8	0	0	9	8	9	9	0	8
Leptostylis sp. Indet.	0	9	0	9	0	0	0	9	0	0	0	0
Leptostylis villosa	0.	0	9	0	0	0	8	0	<b>e</b>	1	9	1
Compylaspis hartae	0	8	0	0	0	9	1	0	0	0	0	1
Campylaspis nodulosa		0	1	0	1	2	0	9	9	1	0	1
Cumella sp. Indet.	0	0	0	0	0	0	0	0	0	0	8	8
Tanaid sp. Indet.	9	0	0	0	0	0	9	9	0	8	8	8
Zeuxo normani	8	0	0	0	9	0	8	0	0	1	9	1
Leptochelia savignyi	8	0	0	0	9	. 0	0	9	9	. 0	0	0
Leptochelia dubia	8	8	0	0	0	0	0	1	0	8	8	1
Leptognathia gracilis	15	8	1	9	0	16	9	0	8	1	9	1
Haliophasma geminata	0	8	0	0	0	0	0	0	0	0	0	0
Limnoria lignorum	. 0	9	0	0	0	0	0	0	0	9	8	8
Symidotea sp. Indet. (juvenile)	8	9	0	0	0	8	0	0	0	0	0	0
Synidotea angulata	ø	8	0	0	8	0	0	0	8	9	0	0
Murma sp. Indet.	1	0	6	1	0	2	0	9	0	8	0	8
Pleurogonium rubicundum	0	8	0	0	0	0	0	1	0	1	0	2
	_	_	_		_	_	_					_

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Munnogonium tillerae Amphipoda sp. Indet.

Gammaridea sp. Indet. Ampelisca agassizi

ASARCO RAW BIOLOGICAL DATA		
TAXON NAME T8-4-A T8-4-B T8-4-C T8-4-D T8-4-E T8-4-TOT T10-1-A T10-1-B T10-1-C T10	)-1-D T10-1-E	T10-1-TOT
Calanus pacificus 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0	О
Paracalanus sp. Indet. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0	9
	0 0	<b>0</b>
Harpacticoida sp. Indet. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	8 8	ā
Peltidiidae sp. Indet. 0 0 0 0 0 0 0 0 0	0 0	a
Typhlampiascus sp. Indet. 8 0 0 0 0 0 0 0 0 8	9 9	a
Rhynchothalestris helgolandica 8 0 0 8 8 0 0 8 8	9 8	ā
Cirripedia sp. Indet. 0 0 0 0 0 0 0 0 0	9 9	a
Scalpellum columbianum 5 1 9 6 3 9 6 6	0 0	å
Balanus sp. Indet. (juvenile) 6 6 6 6 6 6	8 0	a
Balanus crenatus 8 8 8 8 8 8 2 13	39 6	62
	0 0	a
Medalia badessensis	0 0	ā
	a 8	9
and the state of t	0 0	<u> </u>
	9 9	a
	8 8	<b>a</b>
Eudorellopsis longirostris 8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	9 9	4
Diagraph D	0 0	0
Diastylis paraspinulosa 0 0 0 0 0 0 0 0 0	•	
Leptostylis sp. Indet. 0 0 0 0 0 0 0 0	0 0	
Leptostylis villosa 0 0 0 0 0 0 0	0 0	0
Compylaspis hartae 0 0 0 0 0 0 0 0 0	0 0	V
Campylaspis nodulosa 0 1 0 0 1 0 0 0	0 0	0
Cumella sp. Indet. 9 0 0 1 0 1 0 0	0 0	0
Tanaid sp. Indet. 0 0 0 0 0 0 0 0	0 0	V
Zeuxo normani 8 8 0 0 0 0 0 0 0	0 0	Ø.
Leptochelia savignyi 0 0 1 0 0 1 0 0	0 0	0
Leptochelia dubia 0 0 0 0 0 0	0 0	0
Leptognathia gracilis 1 0 0 1 0 2 6 6 0	0 0	0
Haliophasma geminata 2000002000	0 0	0
Limnoria lignorum 0 0 0 0 0 0 0 0	0 0	0
Synidotea sp. Indet. (juvenile) 0 0 0 0 0 0 0	0 0	0
Synidotea angulata 0 0 0 0 0 0 0 0 0	0 0	0
Munna sp. Indet. 0 0 0 0 0 0 0 0	0 0	0
· Pleurogonium rubicundum 6 0 0 0 0 0 0 0	0 0	. 0
Munnogonium tillerae 0 0 0 0 0 0 1 3 2	0 0	6
Amphipoda sp. Indet. 0 0 0 0 0 0 1 1 2	0 0	<b>→</b>
Gammaridea sp. Indet. 0 0 0 0 0 0 0 0	0 0	ø
Ampelisca agassizi 1 1 0 1 2 5 0 0 0	9 0	0

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ASARCO RAW BIOLOGICAL DATA TAXON NAME	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-E T1	1-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-T07
<b>.</b>												
Calanus pacificus	0	. 0	0 2	0	0	0	0	0	8	0	0	(
Paracalanus sp. Indet.		8	8 A	0	Ø A	0	1	8	0	8	8	}
Aetideidae sp. Indet.		8 8	8	0	4	9	8	0	0	1	0	
Harpacticoida sp. Indet.		8			0		0	10		0	0	
Harpacticus uniremis		8	0	0 a	Ø	8 8	9 A	9	9	U	8 A	
Peltidiidae sp. Indet.	9	8	0			-	•	9	0	V	0	
Typhlampiascus sp. Indet.	. 0	9	9 9	8	· W	0	0	Ø	U A			
Rhynchothalestris helgolandica	0		•		9	0				8	0	
Cirripedia sp. Indet.	. 0	8	0	V	9	0	0	U	U	9	6	
Scalpellum columbianum	9	0	8	V		0	U	8				ļ
Balanus sp. Indet. (juvenile)	Ø	0	0	U	1	1	Ø	0	Ø	W O	. 1	
Balanus crenatus	. 0	1	0	0	9	1	8		8	V	2	
Nebalia pugettensis	6	9	1	0	0	1	9	0	9	0	0	
Cumacea sp. Indet.	8	. 0	0	0	0	0	0	0	9	. 0	U	
Lampropidae sp. Indet.	8	8	. 8	0	0	0	8	0	0	0	0	
Lamprops.quadriplicata	. 0	0	0	6	9	9	0	0	9	0	0	
Eudorella pacifica	0	0	9	0	8	0	0	0	8	0	0	
Eudorellopsis longirostris	8	8	8	9	0	8	0	0	9	9	9	
Diastylis sp. B	8	. 0	0	8	8	0	0	0	0	1	1	
Diastylis paraspinulosa	0	9	0	0	0	0	8	0	0	0	9	
Leptostylis sp. Indet.	. 0	0	0	0	0	0	0	9	0	0	8	
Leptostylis villosa	8	0	9	0	0	0	0	8	0	9	0	
Compylaspis hartae	0	0	0	8	0	0	0	0	9	0	9	
Campylaspis nodulosa	. 0	0	9	0	0	. 0	0	0	8	0	6	
Cumella sp. Indet.	0	0	0	0	0	0	0	0	0	0	0	1
Tanaid sp. Indet.	0	0	0	0	0	9	0	9	8	0	9	ı
Zeuxo normani	0	0	0	8	9	0	Ø	0	0	0	0	
Leptochelia savignyi	0	0	8	0	8	Ø	9	9	9	0	. 0	
Leptochelia dubia	0	1	0	0	9	1	0	0	8	0	0	
Leptognathia gracilis	9	0	8	0	0	0	ø	0	0	Ø	0	
Haliophasma geminata	1	0	Ø	8	0	1	0	0	8	0	8	
Liunoria lignorum	0	9	9	9	0	0	0	0	Ø	0	9	
Synidotea sp. Indet. (juvenile)	9	i	0	9	0	1	8	0	0	0	8	
Symidotea angulata	0	0	0	0	0	0	0	0	0	0	0	
Munna sp. Indet.	9	0	0	0	Ø	0	0	8	8	8	0	
Pleurogonium rubicundum	0	0	8	8	8	ð	0	0	0	0	0	4
Munnogonium tillerae	0	0	0	0	0	Ø	0	0	0	0	0	
Amphipoda sp. Indet.	0	8	9	8	0	Ø	1	0	0	0	0	
Gammaridea sp. Indet.	8	0	0	. 0	0	0	0	Ø	0	0	9	
Ampelisca agassizi	. 0	1	0	Ð	ō	1	0	0	Ü	0	0	

ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T16-1-A	T16-1-P	T16-1-C	T16-1-D	716-1-E	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	T16-4-D	T16-4-E	T16-4-TOT
Calanus parificus	9	0	0	0	9	0	0	8	•	8	0	0
Paracalanus sp. Indet.	Ö	0	9	0	0	0	9	9	. 8	9	ě	0
Aetideidae sp. Indet.	8	0	8	9	8	0	8	0	9	8	0	0
Harpacticoida sp. Indet.	0	8	0	9	0	ð	8	0	9	0	0	0
Harpacticus uniremis	0	Ø.	0	0	0	8	0	9	0	0	0	0
Peltidiidae sp. Indet.	8	8	0	8	0	8	8	9	9	9	8	0
Typhlampiascus sp. Indet.	0	0	0	0	0	0	0	8	0	0	0	0
Rhynchothalestris helgolandica	0	8	0	0	0	8	0	0	0	9	9	0
Cirripedia sp. Indet.	9	9	0	9	0	0	0	0	0	0	0	0
Scalpellum columbianum	9	0	0	8	0	0	8	9	9	0	0	0
Balanus sp. Indet. (juvenile)	2	1	2	8	0	5	0	8	9	0	0	0
Balanus crenatus	8	0	0	0	1	1	0	9	9	9	9	0
Nebalia pugettensis	6	8	8	8	9	6	3	8	8	1	0	4
Cumacea sp. Indet.	0	0	9	8	0	0	0	0	9	0	0	0
Lampropidae sp. Indet.	1	9	8	1	9	2	0	0	6	0	0	0
Lamprops quadriplicata	8	8	9	9	0	9	9	9	9	9	9	8
Eudorella pacifica	0	1	0	8	1	2	5	0	1	1	0	4
Eudorellopsis longirostris	0	0	8	0	0	0	0	0	0	0	0	0
Diastylis sp. B	0	0	0	8	0	9	0	0	8	0	0	0
Diastylis paraspinulosa	0	0	0	0	0	0	0	8	0	0	9	9
Leptostylis sp. Indet.	8	0	0	8	9	8	0	0	0	0	0	0
Leptostylis villosa	8	0	8	0	8	0	8	9	0	1	0	1
Compylaspis hartae	8	0	8	8	8	0	0	0	8	0	0	0
Campylaspis nodulosa	8	9	0	0	8	8	9	0	0	0	0	0
Cumella sp. Indet.	0	0	0	0	0	0	9	0	0	0	8	0
Tanaid sp. Indet.	8	9	9	0	9	9	8	9	9	0	0	0
Zeuxo normani	0	0	0	0	0	0	0	0	0	0	0	. 0
Leptochelia savignyi	9	9	9	1	1	2	0	0	0	0	Ó	9
Leptochelia dubia	0	0	0	0	0	0	0	0	0	Q	0	0
Leptognathia gracilis	1	6	9	9	0	1	0	8	0	6	0	8
Haliophasma geminata	0	0	0	0	0	0	0	Ø	9	0	0	0
Limnoria lignorum	0	1	0	9	0	1	0	9	9	0	0	0
Symidotea sp. Indet. (juvenile)	0	9	9	8	0	9	0	8	8	0	9	0
Synidotea angulata	0	0	0	0	0	0	0	8	8	0	0	0
Munna sp. Indet.	0	0	0	8	0	0	0	0	0	8	0	0
Pleurogonium rubicundum	5	0	5	1	1	6	0	0	0	0	0	8
Munnogonium tillerae	8	0	Ø	0	0	0	0	0	0	0	8	0
Amphipoda sp. Indet.	0	0	0	, 0	0	0	0	9	0	0	9	0
Gammaridea sp. Indet.	0	8	0	· i	0	1	0	0	8	0	0	0
Ampelisca agassizi	8	8	8	8	8			8	8	8	8	8
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ASARCO RAW BIOLOGICAL DATA TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-T0T	T22-2-A	T22-2-B	T22-2-C	T22-2-D	T22-2-E	T22-2-TOT	i grand i total
Calanus pacificus	0	0	0	8	8	0	0	0	0	8	8	0	
Paracalanus sp. Indet.	9	0	9	. 0	0	Ø	0	6	0	8	9	0	1 1
Aetideidae sp. Indet.	8	0	0	0	0	0	0	0	9	8	8		1 1
Harpacticoida sp. Indet.	8	8	8	8	8	8	8	8	8	8	0	0	1 5
Harpacticus uniremis	1	. 0	8	0	0	1	1	0	0	0	. 0		1 2
Peltidiidae sp. Indet.	0	9	1	0	8	1	9	0	8	8	0	0	i 1
Typhlampiascus sp. Indet.	0	0	8	0	0	. 0	1	0	0	0	1	2	
Rhynchothalestris helgolandica	0	9	0	0	0	8	0	8	0	8	1	1	i 1
Cirripedia sp. Indet.	0	0	9	9	0	9	0	1	9	0	0	1	1 2
Scalpellum columbianum	9	8	0	9	9	9	9	9	0	0	8	0	1 23
Balanus sp. Indet. (juvenile)	14	5	10	4	2	32	8	0	8	8	105	105	1 167
Balanus crenatus	6	11	5	4	3	29	4	1	8	3	9	8	1 137
Nebalia pugettensis	1	1	3	0	0	5	3	8	1	8	0	4	1 17
Cumacea sp. Indet.	9	0	1	ø	8	1	0	0	0	0	8	0	1 1
Lampropidae sp. Indet.	0	6	0	8	1	1	0	0	0	9	9	. 0	1 3
Lamprops quadriplicata	1	0	0	ø	0	1	0	9	0	8	9	8	i 1
Eudorella pacifica	52	33	39	17	27	168	49	23	26	19	23	140	1 355
Eudorellopsis longirostris	1	0	8	9	0	1	1	0	8	1	. 0	5	1 3
Diastylis sp. B	1	6	5	6	3	21	0	0	9	0	. 0	0	1 23
Diastylis paraspinulosa	8	9	9	0	8	0	9	1	0	8	9	1	1 1
Leptostylis sp. Indet.	0	8	9	0	0	8	0	0		0	0	0	1 1
Leptostylis villosa	8	9	9	0	9	0	1	9	8	0	9	1	1 3
Compylaspis hartae	0	0	0	8	0	8	8	0	0	0	0	8	1 2
Campylaspis modulosa		0	1	0	0	1	0	0	1	8	0	1	1 6
Cumella sp. Indet.	3	2	3	1	8	9	1	1	0	. 0	. 0	2	1 12
Tanaid sp. Indet.	0	0	1	0	0	1	1	9	1	8	9	2	1 3
Zeuxo normani	0	0	· 0	8	0	0	0	9	9	0	9	0	1 1
Leptochelia savignyi	17	23	20	9	15	84	18	18	26	15	15	92	1 181
Leptochelia dubia	0	0	0	0	0	0	0	5	0	1	0	6	1 8
Leptognathia gracilis	9	9	0	0	0	9	0	9	0	9	0	8	1 27
Haliophasma geminata	8	0	0	0	0	8	0	0	0	0	8	0	1 3
Limnoria lignorum	9	3	0	9	9	3	0	0	0	0	0	0	1 4
Symidotea sp. Indet. (juvenile)	0	0	0	0	8	9	0	9	0	0	0	- 0	1 1
Synidotea angulata	9	0	0	0	9	9	0	0	0	0	0		1 1
Munna sp. Indet.	0	8	ě	0	9	9	0	_	9	0	0	8	
Pleurogonium rubicundum	<u>a</u>	9	2	0	0	9	9		9	9	9		1 10
Murnogonium tillerae	ō	9	9	0	9	0	0	0	0	9	9		1 6
Amphipoda sp. Indet.	9	9	9	0	9	ě	ø	_	8	0	ě	_	1 9
Gamaridea sp. Indet.	0	ē	0	0	Õ	0	0		0	0	9		
Ampelisca agassizi	9	0	9	ē	9	9	ě	9	9	9	9	9	1 127

ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T2-5-A	T2-5-B	12-5-C	T2-5 <b>-D</b>	T2-5-E T2-5	FTOT .	T3-5-A	T3-5-B	T3-5-C	T3-5-D	T3-5-E	T3-5-TOT
Ampelisca hancocki	8	9	0	0	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	0	0	0	0	0	e	0
Ampelisca cf.unsocalae	0	0	0	0		0	0	0	0	. 0	0	0
Ampelisca lobata	1	0	. 8	6		1	0	0	9	1	0	1
Byblis valeronis	8	0	0	8		9	8	0	0	. 4	9	4
Byblis cf. millsi	8	0	. 0	1		1	0	8	1	9	0	1
Aoroides sp. Indet.	0	0	. 8	. 1		1	8	8	1	0	0	1
Aoroides columbiae	0	0	0	9		9	8	8	0	0	0	0
Acroides intermedius	0	4	0	8		4	4	8	2	23	19	56
Calliopiidae sp. Indet.	0	0	0	0		Ø	0	0	8	0	9	. 0
Calliopius sp. Indet.	8	0	0	9		0	8	0	0	0	9	0
Corophium sp. Indet.	8	8	0	0		0	0	8	0	0	0	0
Corophium ascherusicum	0	0	0	•		0	8	0	0	0	8	9
Dexamonica reduncans	9	8	0	9	•	0	8	· 0	0	9	0	0
Rhachotropis oculata	0	0	0	9		0	0	0	0	9	9	0
Melita sp. Indet. (juvenile)	0	0	0	8		0	0	0	0	0	0	6
Melita desdichada	0	0	0	9		9	è	0	9	8	0	0
Isaeidae sp. Indet.	0	0	0	0		8	2	0	8	8	9	2
Photis sp. Indet.	9	9	9	0		0	0	0	5	0	9	2
Photis brevipes	0	0	0	8		0	0	8	0	21	. 0	21
Photis bifurcata	0	0	9	8		0	9	8	0	0	0	0
Photis lacia	0	0	0	8		9	0	0	0	0	8	8
Protomedeia sp. Indet.	8	0	9	5		2	4	1	2	2	1	19
Protomedeia penates/prudens	8	0	6	0		0	0	0	0	0	0	0
Gammaropsis thompsoni	9	0	9	8		8	0	8	9	0	0	9
Cheirimedeia zotea	0	0	0	9		8	0	0	0	0	8	9
Ischyrocerus sp. Indet.	3	1	1	0		5	0	9	0	9	0	9
Microjassa sp. Indet.	1	1	0	0		2	0	8	0	2	ð	2
Hippomedon sp. Indet.	0	0	1	8		1	1	9	4	5	4	11
Lysianassa holmesi	0	0	0	0		0	0	1	0	0	0	1
Opisa tridentata	0	0	9	1		1	0	8	0	1	. 8	1
Orchomene pacifica	8	0	0	9		8	0	0	8	0	8	0
Orchomene decipiens	9	0	0	8		6	. 0	0	0	0	0	0 -
Pachynus barnardi	0	0	1	0		1	1	0	9	0	0	1
Melphisana sp. Indet.	0	0	0	. 0		0	0	0	0	0	0	0
Gedicerotidae sp. Indet.	0	0	0	0		0	0	0	0	0	0	0
Monoculodes sp. Indet.	0	0	8	9		0	8	0	9	8	0	0
Synchelidium shoemakeri	9	0	1	1		5	0	0	0	0	0	0
Synchelidium rectipalmum	ø	0	9	. 0	:	a	Ä	á	Q	0		A
Westwoodilla caecula	A	ø	0	é		0	6	8	ě	0	0	0
Pardalisca tenuipes	9	ด	8	. 0		9	8	9	8	8	8	a
. a. agrened senathes	v	v	v	•		•	•	•	•	·		•

ASARCO RAW BIOLOGICAL DATA	<b>T</b> / <b>A A</b>	7. 0.5	T. 6 8	<b>7</b> , 6 5	T. 0.5	T/ 0 TOT	76 7 0	** 3.0	77. 3.0	77 3 5	TC 3 C	T. 3 TOT
taxon name	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	76-3-A	T6-3-B	76-3 <b>-</b> C	T6-3-D	16-3-t	T6-3-TO <b>T</b>
Ampelisca hancocki	14	0		8	0	14	0	8	0	6	0	8
Ampelisca cf.unsocalae	8	0	9	0	0	0	0	, 6	0	0	1	1
Ampelisca lobata	0	1	1	26	39	67	8	. 2	8	0	8	2
Byblis valeronis	0	0	0	8	0	0	8	9	0	0	0	0
Byblis cf. willsi	. 8	10	12	2	3	35	7	12	19	10	1	40
Aoroides sp. Indet.	0	0	0	0	0	0	0	9	0	0	0	8
Acroides columbiae	9	8	8	8	9	0	8	8	8	8	8	8
Acroides intermedius	9	0	2	1	8	3	5	8	6	13	3	35
Calliopiidae sp. Indet.	9	9	0	9	0	0	0	8	0	0	0	0
Calliopius sp. Indet.	0	8	1	1	0	2	1	0	1	0	9	5
Corophium sp. Indet.	0	8	0	8	0	0	0	8	8	9	0	0
Corophium ascherusicum	9	0	0	8	0	0	8	0	0	0	0	0
Dexamonica reduncans	1	0	0	0	ò	1	8	8	9	0	0	0
Rhachotropis oculata	9	0	0	8	8	8	0	3	9	0	0	3
Melita sp. Indet. (juvenile)	8	8	0	0	0	9	8	0	8	0	0	0
Melita desdichada	0	9	0	0	0	9	8	0	0	9	0	0
Isaeidae sp. Indet.	9	0	1	8	9	1	8	8	8	1	0	1
Photis sp. Indet.	5	4	14	4	4	28	4	12	1	23	1	41
Photis brevipes	0	3	4	0	8	7	8	8	8	0	0	0
Photis bifurcata	0	0	0	0	8	8	0	0	8	9	ø	0
Photis lacia	8	0	2	9	1	3	1	4	8	5	0	19
Protomedeia sp. Indet.	1	0	8	9	0	1	2	2	0	3	5	9
Protomedeia penates/prudens	9	8	9	8	0	0	0	0	9	0	8	0
Gammaropsis thompsoni	. 0	1	8	0	0	1	1	8	5	1	9	4
Cheirimedeia zotea	0	6	4	8	0	10	0	0	0	0	0	0
Ischyrocerus sp. Indet.	8	0	0	1	0	1	0	1	5	3	0	6
Microjassa sp. Indet.	8	. 8	0	8	2	2	0	1	8	. 6	8	1
Hippomedon sp. Indet.	9	0	0	1	0	. 1	2	1	4	0	3	10
Lysianassa holmesi	9	0	0	8	0	0	5	0	0	0	9	5
Opisa tridentata	0	0	0	8	8	0	0	0	0	9	0	0
Orchomene pacifica	0	0	9	0	0	9	0	0	8	0	Ø	8
Orchomene decipiens	0	0	1	0	9	1	0	8	0	9	0	0
Pachynus barnardi	9	0	0	9	0	0	8	0	0	9	0	3
Melphisana sp. Indet.	9	6	1	0	Ø	1	Ø	0	0	0	8	0
Dedicerotidae sp. Indet.	0	Ø	0	0	0	Ø	0	0	0	3	0	3
Monoculodes sp. Indet.	0	0	0	0	0	0	0	0	8	0	9	0
Synchelidium shoemakeri	0	0	0	0	.9	0	1	0	1	0	2	4
Synchelidium rectipalmum	0	0	0	0	0	Ø	1	8	1	1	ð	3
Westwoodilla caecula	0	0	1	0	0	i	1	0	0	0	0	1
Pardalisca tenuipes	5	3	4	0	0	9	2	0	0	1	0	3

ASARCO RAN BIOLOGICAL DATA TAXON NAME	T8-4-A	T8-4-B	T8-4-€	T8-4-D	T8-4-E	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
A. 11. 1	4-4-4											
Ampelisca hancocki Ampelisca cf.unsocalae	8 A	0	0 3	1	1	<b>0</b> 6	<i>8</i>	,0 <del>0</del>		8	0	. 0 a
Ampelisca lobata	1	5	3 0	, , ,	3	6	A	0	Φ Δ	8	9	. 0
Byblis valeronis	1	С Д	9	A		0	9	Q	0 0	a	a	Δ.
Byblis cf. millsi		7	5	7	5	18	7	9	1	a	9	4
Aoroides sp. Indet.	<u> </u>	g Q	9		a a	0	a	<b>a</b>		5	8	5
Aoroides columbiae	a	a	8	Ä	a	0	a	0	è	a	0	9
Aoroides intermedius	· A	1	10	ž	9	31	5	15	20	ā	14	54
Calliopiidae sp. Indet.	a	å	0	A	Ã	9	a	8	3	8	9	3
Calliopius sp. Indet.	a	Ä	Ã	å	2	5	a	a	a	2	15	17
Corophium sp. Indet.	a	a	a	a	- A	9	a	1	a	. 0	9	1
Corophium ascherusicum		A	. 0	a	9	9	a	A	a	a	a	ā
Dexamonica reduncans	•	a	0	a	۵	. 0	Δ	a	a	a	a	a
Rhachotropis oculata	<u> </u>	<b>A</b>	A	a	a	9	A	۵	٥	a	A	. a
Melita sp. Indet. (juvenile)	1	a	1	ĭ	a	3	a	A	a	a	a	ă
Melita desdichada		Ā	ė	Ā	a	A	5	2	7	5	6	25
Isaeidae sp. Indet.		Ä	A	Ā	a	9	À	9		0	9	0
Photis sp. Indet.	ĭ	3	1	Ã	2	7	2	16	37	A	19	74
Photis brevipes	<u>.</u>	A	å	a	2		3	4	1	a	9	A
Photis bifurcata	. σ	<b>a</b>	۵	a	<b>a</b>	9	A	1	19	a	8	28
Photis lacia	<u> </u>	1	a	a	7	4	9		1 0	a	0	0
Protomedeia sp. Indet.	7		3	7	3	20	Δ	0	2	8	0	2
Protomedela sp. Indet. Protomedela penates/prudens	9	9	9	á	9	9	38	45	94	65	85	327
Gammaropsis thompsoni	5	5	3	و و	7	18	D	43 A	A	A	A	a
Cheirimedeia zotea	9	A	A	a	a	9	a	a	a	a	a	Ä
Ischyrocerus sp. Indet.	2	8	9	<b>a</b>	<u> </u>	8	0	4	Δ.	a	۵	9
Microjassa sp. Indet.	4	0	8	4	a	0	0	o	4	<u>a</u>	a	0
Hippomedon sp. Indet.	D	9	5	Δ.	1	3		<b>a</b>	Δ	<u>a</u>	D	9
Lysianassa holmesi		a	9	4	a	8	0	0	4	a	a	a
•	0	0	8	4		9	A		0 0	D D	a	9
Opisa tridentata	•	0	0	0	<b>u</b>	8	0	4	0	<b>0</b>	9	0
Orchomene pacifica	0	0	9			1	υ Δ	9	0	. 0	0	0
Orchomene decipiens		9	9	,	•		о 0	. 8	<b>U</b> .	. 0	a	0
Pachynus barnardi		_	90 A	•		8	() ()	0 A	0	0 0	0	a
Melphisana sp. Indet.	8	0	•	0	9	0		<b>U</b>	0	<b>U</b>	0 a	9
Oedicerotidae sp. Indet.		0	0	Ø	U	Ø	0	ď	4	τ Δ	σ Δ	υ Δ
Monoculodes sp. Indet.	. 0	0	0	<b>V</b>	V	Ų	<u> </u>	V	V	<b>6</b>		<del>ا</del>
Synchelidium shoemakeri	0	1	0	0	8	ı	0.	7	V	, t		ď
Synchelidium rectipalmum	9	9	0 .	0	9		0.	Ø A	Ų	8	V	Ψ Δ
Westwoodilla caecula	0	0	1	0	0	1	0	0	. 0	9	. 0	0
Pardalisca tenuipes	0	0	0	8	0	. 0	0,	8	V	Ø	Ø	U

asarco ran biological data Taxon name	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-E T	11-7-TOT	T12-1-A	T12-1-B	T12-1-C	T12-1-D	T12-1-E	T12-1-T0T
Ampelisca hancocki	8	8	.0	8	8	0	8	0	6	0	9	0
Ampelisca of unsocalae	. 0	9	1	5	0	. 3	8	0	0	0	0	0
Ampelisca lobata	0	8	0	0	8	9	0	9	0	8	9	0
Byblis valeronis	8	0	8	8	8	0	8	Ú	9	0	8	0
Byblis cf. millsi	8	8	0	0	8	0	0	0	0	0	0	8
Aoroides sp. Indet.	0	0	9	ê	0	8	Ø	9	9	8	9	0
Aoroides columbiae	0	0	0	0	8	9	. 8	0	1	0	1	2
Acroides intermedius	8	12	1	0	8	13	6	7	7	9	1	21
Calliopiidae sp. Indet.	9	8	, <b>8</b>	Ą	.0	0	0	ø	0	0	0	ø
Calliopius sp. Indet.	8	0	0	9	0	8	0	0	, 0	0	0	0
Corophium sp. Indet.	0	0	.0	8	0	0	0	0	, <b>6</b>	0	0	0
Corophium ascherusicum	9	8	8	8	8	8	9	8	1	1	0	. 2
Dexamonica reduncans	0	8	0	8	. 0	9	0	0	0	0	0	8
Rhachotropis oculata	8	0	8	•	9	0	8	8	8	0	0	0
Melita sp. Indet. (juvenile)	8	0	9	0	0	0	9	0	è	0	0	0
Melita desdichada	9	0	9	0	0	0	4	4	Ş	2	0	12
Isaeidae sp. Indet.	0	0	0	0	8	9	0	0	0	0	0	0
Photis sp. Indet.	8	0	0		8	0	6	2	0	7	3	18
Photis brevipes	0	8	8	9	0	0	2	0	0	0	1	3
Photis bifurcata	9	9	0	0	0	0	1	9	1	Ş	0	4
Photis lacia	8	9	8	8	0	0	0	0	0	8	0	8
Protomedeia sp. Indet.	0	8	0	9	Ģ	0	0	0	0	. 0	8	9
Protomedeia penates/prudens	8	2	0	9	0	2	25	13	7	164	36	245
Gammaropsis thempsoni	9	2	9	8	0	2	9	8	Ģ	. 0	9	0
Cheirimedeia zotea	8	9	0	8	0	0	0	0	0	9	0	9
Ischyrocerus sp. Indet.	9	0	0	8	0	8	0	8		8	0	0
Microjassa sp. Indet.	0	8	' Ø	. 0	8	0	9	8	0	8	0	8
Hippowedon sp. Indet.	0	1	1	0	0	2	9	9	8	8	0	Ø
Lysianassa holmesi	0	0	8	9	0	0	<b>Ø</b>	Ø	8	0	. 0	0
Opisa tridentata	9	0	0	9	0	9	ø	0	. 8	0	9	- 8
Orchomene pacifica	0	8	1	0	8	1	0	0	0	0	0	0
Orchomene decipiens	0	0	0	0	8	0	9	0	0	0	. 0	8
Pachynus barnardi	0	0	0	0	8	0	0	8	0	0	8	<b>0</b> .
Melphisana sp. Indet.	0	0	. 0	9	0	0	9	0	9	9	9	8
Dedicerotidae sp. Indet.	8	0	0	8	0	0	0	0	8	0	8	ø
Monoculodes sp. Indet.	9	8	. 0	0	0	8	0	9	0	0	9	8
Synchelidium shoemakeri	8	0	1	8	0	1	0	0	8	0	0	9
Synchelidium rectipalmum	8	0	9	0	0	0	0	0	9	0	9	9
Westwoodilla caecula	8	8	9	8	9	9	. 8	8	8	9	9	0
Pardalisca tenuipes	9	9	0	0	0	0	0	0	0	0	0	ð

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T16-1-A	T16-1-B	T16-1-C	T16-1-D	T16-1-E	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	T16-4-D	T16-4-E	T16-4-TOT
Ampelisca hancocki	8	1	1	0	0	2	0	9	0	0	0	0
Ampelisca of unsocalae	0	0	9	0	8	0	1	0	9	0	0	1
Ampelisca lobata	9	0	9	0	8	0	8	9	8	8	8	9
Byblis valeronis	0	0	0	8	0	0	0	0	8	8	9	8
Byblis cf. millsi	1	0	0	1	2	4	0	8	0	0	0	8
Aoroides sp. Indet.	0	1	0	5	0	3	0	8	0	0	0	8
Aoroides columbiae	9	0	0	0	8	9	0	8	0	9	0	0
Aoroides intermedius	8	8	8	8	6	6	8	8	6	9	0	. 6
Calliopiidae sp. Indet.	0	0	0	. 8	8	0	0	8	0	0	8	0
Calliopius sp. Indet.	0	0	8	8	0	0	8	9	8	0	0	8
Corophium sp. Indet.	0	0	0	8	9	9	ø	0	0	0	0	6
Corophium ascherusicum	0	9	9	9	9	0	ė	9	9	9	9	0
Dexamonica reduncans	8	9	8	•		8	0	0	8	6	0	9
Rhachotropis oculata	8	8	9	9	9	8	0	9	9	0	9	9
Melita sp. Indet. (juvenile)	9	0	0	8	0	9	0	8	•	8	0	0
Melita desdichada	8	8	0	8	6	6	0	0	0	0	0	0
Isaeidae sp. Indet.	9	9	9.	9	0	8	9	0	8	. 6	8	6
Photis sp. Indet.	8	8	1	0	2	3	6	9	0	. 0	0	0
Photis brevipes	0	8	0	8	1	1	0	0	0	0	0	0
Photis bifurcata	0	0	9	0	0	0	0	0	9	0	0	8
Photis lacia	8	0	0	8	8	0	8	0	8	0	6	1 0
Protomedeia sp. Indet.	0	5	9	9	0	2	8	8	0	8	9	8
Protomedeia penates/prudens	3	0	3	8	5	11	2	2	1	1	8	6
Gammaropsis thompsoni	0	0	0	1	0	1	. 8	8	. 6	9	. 0	0
Cheirimedeia zotea	0.	9	0	9	0	0	0	0	0	0	8	9
Ischyrocerus sp. Indet.	0	9	0	9	. 0	8	0	0	0	0	e	9
Microjassa sp. Indet.	9	0	0	9	9	. 0	9	9	8	8	9	8
Hippomedon sp. Indet.	4	0	5	0	0	6	1	1	. 0	0	e	2
Lysianassa holmesi		9	0	0	0	0	0	0	0	0	0	9 0
Opisa tridentata	0	9	0	0	0	9	0	0	0	9	8	9
Orchomene pacifica	0	0	0	0	Ø		. 3	2	9	2	6	7
Orchomene decipiens	. 0	0	9	9	8	0	. 0	8	8	. 0	(	8
Pachynus barnardi	9	0	8	0	Q	e e	0	0	9	0	(	9 6
Melphisana sp. Indet.	9	9	8	0	e	9	0	8	0	0	(	0
Oedicerotidae sp. Indet.	9	0	0	0	e	9	0	0	9	Ø	(	9 9
Monoculodes sp. Indet.	A	ā	A	Ā	ā	9	0	8	0	0	. (	9 0
Synchelidium shoemakeri	5	3	9	2		8	i	9	0	0	(	<b>3</b> 1
Synchelidium rectipalmum	a	0	9	0	. 6	j. 0	9	6	0	0	(	8 0
Westwoodilla caecula		8	-	ž			-	. 0	1	0		0 1
Pardaliscă tenuipes	0	8		0	-			_	9	•		9 8

asarco raw biological data Taxon name	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-TOT	T22-2-A	T22-2-B	T22-2-C	T22-2-D	T22-2-€	T22-2-TOT		GRAND TOTAL
Ampelisca hancocki	8	1	8	0	0	1	9	2	1	8	8	3	ı	20
Ampelisca cf.unsocalae	0	0	0	8	0	0	8	0	0	9	0	0	i	11
Ampelisca lobata	0	0	0	8	8	0	4	0	0	0	. 0	4	-	81
Byblis valeronis	9	0	0	8	9	0	0	0	0	9	0	0	ı	4
Byblis cf. millsi	8	0	3	0	0	3	3	8	1	1	1		ı	115
Aoroides sp. Indet.	3	4	0	0	5	9	0	6	2	8	' <b>0</b>	2	ŀ	21
Aoroides columbiae	0	8	9	0	8	0	9	0	0	9	0	0	1	5
Aoroides intermedius	6	0	1	2	0	9	8	8	9	8	1	_	1	233
Calliopiidae sp. Indet.	9	9	8	8	0	8	8	9	0	9	8	9	ł	3
Calliopius sp. Indet.	0	0	2	. 1	0	3	0	1	9	0	1	5	ł	28
Corophium sp. Indet.	8	8	0	8	8	9	0	0	0	8	9	0	1	1
Corophium ascherusicum	8	8	1	8	8	1	8	8	8	8	8	8	i	3
Dexamonica reduncans	6	14	6	4	8	38	0	0	0	9	0	0	ŀ	39
Rhachotropis oculata	Ø.	9	8	0	8	0	8	0	9	0	8	0	1	3
Melita sp. Indet. (juvenile)	8	0	0	0	8	9	8	0	0	9	8	_	J	3
Melita desdichada	7	5	2	4	4	55	1	8	0	0	2	3	ı	68
Isaeidae sp. Indet.	0	9	8	. 0	0	0	Ø	8	9	1	0	1	ı	5
Photis sp. Indet.	2	8	1	3	1	7	0	0	1	. 6	0	1		181
Photis brevipes	0	5	1	0	0	3	0	0	9	0	0	0	i	43
Photis bifurcata	0	0	8	ø	0	0	0	8	0	0	8	0	J	32
Photis lacia	. 0	0	8	9	8	0	9	9	8	9	0	0	1	17
Protomedeia sp. Indet.	1	0	0	9	8	1	0	0	0	8	0	0	i	47
Protomedeia penates/prudens	0	0	0	9	0	8	9	9	0	9	9	8	i	591
Gammaropsis thompsoni	0	0	0	0	8	0	9	0	0	0	0	0	1	26
Cheirimedeia zotea	0	0	0	0	9	0	0	0	0	9	0	0	ı	10
Ischyrocerus sp. Indet.	0	0	0	8	8	9	0	0	9	0	9	0	ļ	12
Microjassa sp. Indet.	9	0	9	0	8	0	9	0	0	9	9	0	}	7
Hippomedon sp. Indet.	9	0	0	9	0	0	0	0	0	1	0	1	1	37
Lysianassa holmesi	0	0	0	0	0	9	0	0	0	9	0	0	ŀ	6
Opisa tridentata	0	0	0	0	6	0	0	0	0	0	ø	0	1	2
Orchomene pacifica	0	8	0	. 0	0	0	0	Ø	0	0	0	8	1	8
Orchomene decipiens	0	9	0	0	0	Ø	0	1	1	0	1	3	1	5
Pachynus barnardi	0	0	0	0	0	0	1	Ø	0	3	0	4	ŀ	6
Melphisana sp. Indet.	0	8	0	0	8	0	Ø	0	0	9	0	0	ł	1
Oedicerotidae sp. Indet.	8	0	0	8	8	0	0	6	0	0	0	0	ı	3
Monoculodes sp. Indet.	3	9	4	3	2	3	1	0	0	0	8	i	١	10
Synchelidium shoemakeri	1	0	Ø	0	0	. 1	Ŋ	0	0	0	0	0	ı	18
Synchelidium rectipalmum	0	2	1	1	1	5	3	0	0	0	8	3	1	11
Westwoodilla caecula	4	9	1	0	1	6	3	9	9	8	3	6	1	34
Pardalisca tenuipes	0	0	Ø	0	8	0	0	1	0	0	0	1	1	13

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T2-5-A	T2-5-B	T2-5-C	T2-5-D	T2-5-E T2-5-TOT	T3-5-A	T3-5-B	T3-5-C	T3-5-D	T3-5-E	T3-5-TOT
Phoxocephalidae sp. Indet.	0		0	8			<u>-</u>	8	e	0	
Heterophoxus oculatus	8	0	8	9	0	8	0	9	1	0	1
Metaphoxus frequens	9	1	8	1	2	0	0	1	0	6	. 1
Metaphoxus fultoni	A	0	8	0	8	0	9	0	0	9	0
Rhepoxynius daboius	ē	0	Ō	0	0	8	8	0	0	0	0
Parapleustes sp. Indet.	0	0	9	0	. 8	1	8	0	0	1	2
Pleusymtes subglaber	9	9	0	8	• 0	8	0	8	8	0	0
Dulichia cf. falcata	9	0	9	0	0	0	1	4	0	0	5
Dulichia sp. Indet.	9	8	0	8	0	0	8	9	1	0	1
Dyopedos sp. Indet.	0	0	0	0	0	8	1	2	8	. 2	5
Paradulichia typica	. 0	0	0	8	0	0	1	4	8	8	21
Podocerus cristatus	0	0	0	8	0	0	8	9	8	9	0
Stenothoidae sp. Indet.	1	. 1	0	9	5	8	0	2	2	5	9
Tiron biocellata	8	0	6	8	0	0	9	8	0	0	0
Hyperiidea sp. Indet. (juvenile)	0	0	0	0	0	0	0	8	0	0	0
Hyperiidae sp. Indet. (juvenile)	9	0	8	0	0	0	0	0	0	0	0
Parathemisto pacifica	0	0	0	8	0	0	0	8	0	0	0
Caprellidea sp. Indet.	8	. 9	1	8	1	8	0	0	8	6	9
Caprellidae sp. Indet.	9	0	8	8	0	0	0	0	0	. 0	0
Mayerella banksia	8	0	8	8	9	9	0	0	9	8	0
Tritella pilimana	8	0	1	1	- 2	7	.4	26	25	9	62
Caprella mendax	8	0	0	8	. 8	9	1	0	9	0	1
Caprella striata	0	2	8	8	2	8	8	1	0	0	1
Decapoda (?Hemigrapsus sp.)	8	0	8	8	9	0	0	8	0	9	9
Coridea sp. Indet.	0	0	0	8	0	0	0	8	0	0	0
Hippolytidae sp. Indet.	0	0	0	0	0	8	8	0	0	0	0
Spirontocaris sp. Indet.	0	8	0	0	8	8	0	0	8	. 0	0
Eualus pusiolus	0	0	9	8	0	0	8	0	0	9	0
Crangonidae sp. Indet.	0	0	0	0	0	0	0	. 0	. 0	0	0
Cragnon sp. Indet.	. 0	0	9	8	0	6	0	9	9	0	9
Anomura sp. Indet. (larvae)	0	0	8	0	0	8	0	8	. 0	0	0
Axiopis spinulicauda	8	8	0	0	Ø	0	0	0	0	0	0
Callianassa sp. Indet. (juvenile)	9	0	Ø	0	. 0	0	0	8	0	9	0
Paguridae sp. Indet.	0	0	8	8	0	8	0	0	9	8	0
Pagurus sp. Indet.	0	0	0	. 0	0	2 .	8	0	0	0	. 2
Porcellanidae sp. Indet.	9	0	0	9	8	<b>0</b> .	9	8	0	9	0
Brachyura sp. Indet. (larvae)	9	0	0	0	0	0	0	0	0	0.	. 0
Oregonia gracilis	0.	0	0	. 0		8	0	0	9	0	
Pugettia gracilis	. 1	9	0	0	1	0.	0	8	0	0	0
Cancer sp. Indet. (larvae & juvenile)	8	0	8	A	8	8	9	0	0	0	9

ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-8	T6-3-C	T6-3-D	T6-3-E	T6-3-TOT
Phoxocephalidae sp. Indet.	. 0	0	0	0	0	0	0	8	0	0	0	0
Heterophoxus oculatus	. 0	8	9	Ø	9	9	9	1	8	8	8	1
Metaphoxus frequens	0 -	0	1	0	8	1	0	0	8	0	1	1
Metaphoxus fultoni	0	1	0	1	1	3	0	9	8	8	0	0
Rhepoxynius daboius	0	0	0	9	9	8	0	0	. 0	8	0	9
Parapleustes sp. Indet.	8	9	0	8	9	0	2	3	0	4	0	9
Pleusymtes subglaber	0	0	0	0	0	0	0	9	0	0	. 6	6
Dulichia cf. falcata	0	. 0	0	0	9	0	0	9	0	9	0	0
Dulichia sp. Indet.	9	8	0	9	8	0	0	0	0	0	6	8
Dyopedos sp. Indet.	0	9	8	0	9	0	0	0	8	0	9	0
Paradulichia typica	0	0	0	0	0	6	2	0	8	0	Ø	2
Podocerus cristatus	8	0	0	0	9	8	0	8	0	0	0	8
Stenothoidae sp. Indet.	4	0	1	4	1	10	8	. 0	8	1	0	1
Tiron biocellata	0	6	9	6	3	24	0	8	0	Ø	0	8
Hyperiidea sp. Indet. (juvenile)	8	9	0	0	0	0	0	8	8	0	8	0
Hyperiidae sp. Indet. (juvenile)	9	0	0	9	0	9	0	8	0	9	9	8
Parathemisto pacifica	8	0	0	8	. 0	0	0	0	8	0	. 0	8
Caprellidea sp. Indet.	9	0	0	0	0	9	6	0	0	1	9	1
Caprellidae sp. Indet.	9	0	0	8	e	0	0	1	1	2		4
Mayerella banksia	9	9	9	8	0	0	0	8	8	8	0	9
Tritella pilimana	52	63	188	42	41	386	74	141	12	250	2	479
Caprella mendax	0	5	0	0	9	2	1	14	1	3	8	19
Caprella striata	0	0	0	0	0	0	8	0	8	8	0	8
Decapoda (?Hemigrapsus sp.)	6	0	9	8	8	0	0	0	0	0	0	Ø
Coridea sp. Indet.	8	8	0	1	1	2	1	8	1	9	0	2
Hippolytidae sp. Indet.	8	9	9	8	9	0	0	9	0	1	0	1
Spirontocaris sp. Indet.	0	0	0	0	. 0	9	0	0	0	1	9	1
Eualus pusiolus	0	8	9	. 0	1	1	0	0	9	0	8	0
Crangonidae sp. Indet.	. 8	0	0	8	9	8	8	8	0	2	0	2
Cragnon sp. Indet.	0	9	8	6	8	0	0	0	0	0	8	0
Anomura sp. Indet. (larvae)	1	1	0	9	8	2	8	0	•	8	8	9
Axiopis spinulicauda	9	0	9	0	0	9	ø	0	9	0	9	9
Callianassa sp. Indet. (juvenile)	9	8	0	0	6	3	0	0	٠ 0	0	8	0
Paguridae sp. Indet.	0	0	0	0	0	0	0	0 :	. 0	0	0	9
Pagurus sp. Indet.	0	9	9	0	0	9	0	<b>e</b> '	0	0	. 1	1
Porcellanidae sp. Indet.	0	0	0	1	0	1	0	0	1	0	0	1
Brachyura sp. Indet. (larvae)	0	0	0	9	9	0	0	0	9	0	0	0
Oregonia gracilis	0	0	0	8	0	0	0	0	0	0	0	9
Pugettia gracilis	2	. 0	3	5	8	18	0	i	1	5	0	4
Cancer sp. Indet. (larvae & juvenile)	3	2	2	3	1	11	3	0	0	1	1	5

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ASARCO RAW BIOLOGICAL DATA TAXON NAME	T8-4-A	T8-4-B	T8-4-C	T8-4-D	18-4-E	T8-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	T10-1-E	T10-1-TOT
Phoxocephalidae sp. Indet.	9	9	1	8	9	1	8	8	8	0	0	. 0
Heterophoxus oculatus	0	1	8	1	0	2	9	1	9	8	0	1
Metaphoxus frequens	8	8	8	0	8	0	8	9	.0	0	0	0
Metaphoxus fultoni	8	8	0	0	0	0	8	9	0	0	0	. 0
Rhepoxynius daboius	0	0	0	1	. 1	2	0	0	9	0	0	0
Parapleustes sp. Indet.	9	0	8	8	1	1	9	0	0	0	8	0
Pleusymtes subglaber	0	0	0	8	0	8	0	2	.1	0	0	3
Dulichia cf. falcata	0	0	9	0	8	9	9	0	9	9	. 0	8
Dulichia sp. Indet	0	0	0	9	0	0	0	0	9	0	0	. 0
Dyopedos sp. Indet.	0	0	0	0	0	9	0	8	0	9	0	0
Paradulichia typica	8	8	0	8	9	0	. 0	0	0	9	0	0
Podocerus cristatus	8	8	9	8	1	1	6	8	8	8	8	6
Stenothoidae sp. Indet.	1	0	0	9	0	1	0	8	0	0	0	0
Tiron biocellata	0	8	0	9	0	8	8	9	0	0	0	0
Hyperiidea sp. Indet. (juvenile)	0	0	0	0	0	0	0	6	8	0	0	0
Hyperiidae sp. Indet. (juvenile)	8	. 0	0	9	9	0	0	0	8	0	0	9
Parathemisto pacífica	0	9	0	0	0	0	8	0	8	0	0	0
Caprellidea sp. Indet.	8	0	0	9	9	9	8	0	8	8	8	8
Caprellidae sp. Indet.	0	0	0	1	9	1	0	0	0	9	. 9	9
Mayerella banksia	0	8	0	9	0	0	4	9	12	8	7	40
Tritella pilimana	14	65	35	32	35	181	5	5	5	2	0	17
Caprella mendax	2	45	0	3	3	53	0	9	8	8	0	9
Caprella striata	0	0	0	8	8	8	8	0	0	0	0	0
Decapoda (?Hemigrapsus sp.)	0	9	8	0	0	0	0	9	9.	8	0	9
Coridea sp. Indet.	0	0	0	8	0	0	4	9	1	0	0	5
Hippolytidae sp. Indet.	0	0	0	0	0	0	0	0	9	8	0	0
Spirontocaris sp. Indet.	9	0	0	9	. 0	0	0	9	0	0	0	8
Eualus pusiolus	1	3	2	1	2	9	8	•	6	0	8	0
Crangonidae sp. Indet.	1	1	8	9	9	2	8	3	2	2	0	15
Cragnon sp. Indet.	8	0	0	8	9	0	9	1	0	0	0	1
Anomura sp. Indet. (larvae)	9	0	0	0	0	0	0	0	0	0	0	0
Axiopis spinulicauda	9	9	9	1	0	1	0	0	0	0	9	8
Callianassa sp. Indet. (juvenile)	0	0	0	8	9	9	0	9	. 0	0	0	0
Paguridae sp. Indet.	ā	0	0	0	9	0	9	0	1	0	0	1
Pagurus sp. Indet.	0	1	1	8	8	2	0	1	9	3	0	5
Porcellanidae sp. Indet.	0	0	9	0	9	0	0	8	0	i	9	i
Brachyura sp. Indet. (larvae)	ă	0	0	ě	a	0	Ö	0	8	0	0	8
Oregonia gracilis	. a	0	0	0	a	0	8	ž	9	0	1	3
Dugettia gracilis	1	5	0	0	1	: 7	ø	1	ė	0	2	3
	1	3	5	9	5	. 8	12	8	6	14	5	46
Cancer sp. Indet. (larvae & juvenile)	1	3	Č	₹	ς.		ıč	•	0	47	·	,0

ASARCO RAW BIOLOGICAL DATA												
TAXON NAME	T11-7-A	T11-7-B	T11-7-C	T11-7-D	T11-7-E	T11-7-TOT	T12-1-A	T12-1-B	T12-1 <b>-</b> C	T12-1-D	T12-1-E	T12-1-T0T
Phoxocephalidae sp. Indet.	8	0	0	9	9	0	0	0	8	0	0	0
Heterophoxus oculatus	8	. 8	0	8	8	8	8	0	9	8	0	8
Metaphoxus frequens	1	1	2	0	0	4	0	0	8	0	0	0
Metaphoxus fultoni	9	8	8	8	Ù	0	0	6	8	1	0	1
Rhepoxynius daboius	3	1	8	1	3	16	8	0	8	8	9	8
Parapleustes sp. Indet.	9	5	8	0	8	2	0	6	8	8	8	ø
Pleusymtes subglaber	0	8	0	9	0	0	0	0	1	1	8	2
Dulichia cf. falcata	9	9	0	9	9	9	0	8	9	9	9	8
Dulichia sp. Indet.	8	ě	9	9	8	8	. 8	0	8	0	0	0
Dyopedos sp. Indet.	0	9	Ģ	₽	8	0	0	8	8	8	. 8	8
Paradulichia typica	8	0	9	. 9	8	0	8	8	0	0	0	0
Podocerus cristatus	0	. 0	9	0	0	8	0	9	0	0	0	9
Stenothoidae sp. Indet.	0	1	8	0	9	1	0	0	9	0	0	0
Tiron biocellata	9	9	9	8	0	0	0	9	0 .	9	0	9
Hyperiidea sp. Indet. (juvenile)	9	9	0	0	0	0	0	9	0	8	8	0
Hyperiidae sp. Indet. (juvenile)	9	0	0	0	ė.	. 0	0	0	9	0	0	9
Parathemisto pacifica	0	0	0	0	. 0	0	0	9	8	9	9	0
Caprellidea sp. Indet.	0	0	0	8	0	8	8	9	9	0	0	ø
Caprellidae sp. Indet.	9	0	8	1	0	1	8	9	8	9	0	0
Mayerella banksia	0	Ģ	8	0	0	0	5	1	1	34	7	48
Tritella pilimana	9	ø	8	8	0	0	1	1	8	0	ø	2
Caprella mendax	0	0	9	Ģ	0	0	0	0	0	0	•	Ģ
Caprella striata	0	0	0	9	0	8	9	9	0	0	0	0
Decapoda (?Hewigrapsus sp.)	0	8	0	8	0	8	8	8	0	9	8	0
Coridea sp. Indet.	9	9	0	0	0	2	0	0	8	8	0	0
Hippolytidae sp. Indet.	0	0	9	9	0	0	0	8	0	9	9	0
Spirontocaris sp. Indet.	8	0	0	0	. 0	0	0	0	0	0	0	0
Eualus pusiolus	8	0	8	8	0	9	0	8	9	9	9	9
Crangonidae sp. Indet.	9	0	0	8	9	0	0	6	0	0	0	0
Cragnon sp. Indet.	0	0	0	8	8	0	9	8	8	0	9	0
Anomura sp. Indet. (larvae)	8	8	9	8	8	0	9	i	8	i	8	2
Axiopis spinulicauda	8	0	0	8	0	0	9	9	0	0	Ø	0
Callianassa sp. Indet. (juvenile)	0	0	0	8	9	0	0	0	9	1	0	1
Paguridae sp. Indet.	9	0	Ø	8	Ø	9	9	0	0	9	0	9
Pagurus sp. Indet.	8	1	0	8	0	1	0	2	1	Ø	0	3
Porcellamidae sp. Indet.	8	0	Ú	8	0	0	0	0	0	0	0	0
Brachyura sp. Indet. (larvae)	0	0	0	0	8	0	0	0	0	0	0	0
Oregonia gracilis	9	0	Ü	9	9	.0	0	9	0	•	8	0
Pugettia gracilis	0	0	0	0	0	0	Ŋ	0	1	0	0	1
Cancer sp. Indet. (larvae & juveni	le) Ø	. 1	8	0	0	1	5	1	3	1	0	7

ASARCO RAW BIOLOGICAL DATA							0					
TAXON NAME	T16-1-A	T16-1-B	T16-1-C	T16-1-D	T16-1-E	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	716-4-D	T16-4-E	T16-4-TOT
,,,,, <u>,</u> ,,												
Phoxocephalidae sp. Indet.	9	0	0	0	0	0	8	0	0	0	0	0
Heterophoxus oculatus	0	0	9	0	. 0	0	8	. 0	8	0	0	0
Metaphoxus frequens	1	0	0	9	0	1	2	1	2	2	1	- <b>8</b>
Metaphoxus fultoni	0	0	0	8	1	1	9	9	8	0	0	0
Rhepoxynius daboius	0	0	0	8	9	8	7	8	6	8	5	34
Parapleustes sp. Indet.	0	0	9	8	0	9	8	0	0	0	0	0
Pleusymtes subglaber	0	0	0	0	9	0	0	9	0	0	0	0
Dulichia cf. falcata	0	0	0	0	0	9	0	0	0	0	0	0
Dulichia sp. Indet.	0	0	0	0	0	0	0	8	8	0	0	0
Dyopedos sp. Indet.	0	0	0	8	9	8	8	0	0	0	0	9
Paradulichia typica	0	0	0	0	0	0	0	0	0	0	0	0
Podocerus cristatus	8	6	0	8	0	0	8	0	8	8	0	0
Stenothoidae sp. Indet.	9	0	0	0	0	0	0	0	9	8	0	0
Tiron biocellata	0	8	8	8	0	0	8	8	8	0	0	8
Hyperiidea sp. Indet. (juvenile)	8	. 6	0	0	9	0	0	0	0	8	0	0
Hyperiidae sp. Indet. (juvenile)	0	9	. 8	8	9	8	0	9	8	9	8	0
Parathemisto pacifica	. 0	8	0	1	0	1	0	0	8	8	0	0
Caprellidea sp. Indet.	9	9	9	9	8	8	0	1	0	9	1	2
Caprellidae sp. Indet.	0	0	0.	8	8	0	0	0	0	0	0	6
Mayerella banksia	0	0	1	9	9	1	9	8	0	9	0	9
Tritella pilimana	9	1	3	1	0	5	9	0	9	0	0	Ø
Caprella mendax	9	0	0	ė	0	0	0	8	0	8	0	8
Caprella striata	9	0	0	0	0	9	0	0	0	0	0	0
Decapoda (?Hemigrapsus sp.)	8	0	8	0	8	0	0	9	8	0	. 0	8
Coridea sp. Indet.	8	0	0	0	. 0	0	6	8	0	0	0	8
Hippolytidae sp. Indet.	8	0	0	0	. 8	0	0	9	0	0	9	0
Spirontocaris sp. Indet.	0	0	0	0	0	0	0	0	0	6	0	0
Eualus pusiolus	0	0	0	0	9	8	ė	9	0	8	0	0
Crangonidae sp. Indet.	1	0	0	8	8	1	0	0	8	9	8	0
Cragnon sp. Indet.	1	9	8	0	0	1	0	9	0	0	9	8
Anomura sp. Indet. (larvae)	0	8	8	8	9	9	0	9	9	9	8	9
Axiopis spinulicauda	0	0	0	8	0	0	, , , ,	. 0	. ,0	, . O.	., 0	1. · · • •
Callianassa sp. Indet. (juvenile)	0	9	0	0	0	. 0	0	. 0	0	9	0	. 0
Paguridae sp. Indet.	0	0	0	0	0	0	9	0	0	9	0	9
Pagurus sp. Indet.	9	0	0	0	1	1	0	0	0	0	0	0 ;
Porcellanidae sp. Indet.	0	0	9	9	0	0	0	0	0	0	9	. 0
Brachyura sp. Indet. (larvae)	0	9	8	8	0	0	. 2	0	0	<b>0</b> :	8	,. <b>2</b>
Oregonia gracilis	9	9	0	0	6	. 0	0,	0	0	0	0	9
Pugettia gracilis	Ò	0	0	0	· 0	'. 1	0	0	0	0.	. 0	0
Cancer sp. Indet. (larvae & juvenile)	1	1	0	s	5	6	0	0	0.	6	8	6

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1-D	T22-1-E	T22-1-T0T	T22-2-A	T22-2-B	T22-2-C	T22-2-D	T22-2-E	T22-2-T0T	I GRAND I TOTAL
Phoxocephalidae sp. Indet.	0	0	8	0	0	0	Q	9	8	0	8	0	1 1
Heterophoxus oculatus	10	8	10	3	9	40	9	3	8	6	6	32	•
Metaphoxus frequens	8	0	0	0	0	0	1	0	. 0	9	9	1	1 19
Metaphoxus fultoni	35	17	13	55	55	106	24	3	16	15	10	68	
Rhepoxymius daboius	0	8	0	0	0	8	0	9	0	0	0	Ø	
Parapleustes sp. Indet.	8	8	0	1	0	1	0	0	0	8	0	0	1 15
Pleusymtes subglaber	8	2	0	8	2	4	8	0	0	8	8	0	1 9
Dulichia cf. falcata	0	0	8	9	8	8	0	9	9	0	0	0	1 5
Dulichia sp. Indet.	8	0	8	. 0	0	0	0	0	0	0	0	0	1 1
Dyopedos sp. Indet.	8	0	0	9	2	2	0	0	0	0	9	8	1 7
Paradulichia typica	8	8	0	9	8	8	0	0	8	0	0	9	1 23
Podocerus cristatus	8	8	. 6	9	8	8	8	8	8	8	9	8	1 1
Stenothoidae sp. Indet.	8	0	9	8	0	0	0	0	0	0	9	0	1 24
Tiron biocellata	1	0	0	0	0	1	9	0	0	0	0	0	1 25
Hyperiidea sp. Indet. (juvenile)	0	0	8	8	9	0	0	0	8	9	1	1	1 1
Hyperiidae sp. Indet. (juvenile)	8	8	8	9	9	. 8	9	9	9	1	9	1	
Parathemisto pacifica	8	0	0	8	0	0	0	0	9	0	0	0	1 1
Caprellidea sp. Indet.	1	1	0	0	1	3	8	1	0	0	8	1	1 8
Caprellidae sp. Indet.	1	1	0	1	2	. 5	0	4	1	1	1	7	1 27
Mayerella banksia	0	0	. 0	0	9	0	0	0	0	0	9	0	
Tritella pilimana	14	1	0	. 0	0	15	1	0	Ø	1	0		1 1151
Caprella mendax	0	8	9	0	0	0	0	0	0	8	0	0	
Caprella striata	8	0	0	0	0	0	0	0	9	0	9	ø	1 3
Decapoda (?Hemigrapsus sp.)	. 0	9	i	9	0	1	0	8	0		9	0	
Coridea sp. Indet.	9	9	7	0	1	17	5	0	0	0	8	5	
Hippolytidae sp. Indet.	0	ø	0	9	0	0	0	0	8	8	0	ø	
Spirontocaris sp. Indet.	0	9	0	0	0	0	0	0	0	0	8	8	
Eualus pusiolus	2	9	Ø	9	9	0	Ü	8	0	0	0	8	
Crangonidae sp. Indet.	3	2	9	1	i	16	0	0	ø	0	0	0	
Cragnon sp. Indet.	0	0	9	0	1	1	0	0	ō	9	0	0	
Anogura sp. Indet. (larvae)	0	0	0	0	0	0	Ø	0	0	Ø	0	0	
Axiopis spinulicauda	8	8	9	0	0	. 13	Ù	Ū.	9	9	9	Ø	1 1
Callianassa sp. Indet. (juvenile)	0	0	0	8	0	0	0	ø	0	0	0	0	
Paguridae sp. Indet.	0	0	Ø	9	0	0	0	0	0	0	0	9	
Pagurus sp. Indet.	1	6	2	0	1	10	0	1	8	0	ø	1	
Porcellanidae sp. Indet.	0	8	1	9	9	1	9	9	9	9	9	9	
Brachyura sp. Indet. (larvae)	0	1	3	Ø	0	1	0	ø	ø	0	0	0	
Oregonia gracilis	1	Ū	. 0	0	1	2	0	ø	o o	9	9	9	
Pugettia gracilis		0	ě	8	ė	0	9	0	ø	0	9	8	1 34
Cancer sp. Indet. (larvae & juvenile)	16	8	8	5	8	45	3	1	3	4	5	13	

ASARCO RAW BIOLOGICAL DATA	<b>7</b> 0 F 0	T2 E 0	<b>T</b> 2 <b>F P</b>	T2-5-D	72-5-E	T2-5-TOT	T3-5-A	73-5-B	T3-5-C	T3-5-D	13-5-E	T3-5-TOT
TAXON NAME	T2-5-A	T2-5-B	T2-5-C	ע־פּרטו	16-J-E	16-3-101	10-0-H	13-J-b				
Cancer productus	8	0	. 0			. 0	. 0	8	8	0	0	
Lophopanopeus (megalops)	8	0	6	9		0	0	0	0	0	0	0
Lophopanopeus bellus (larvae & adult)	0	0	8	0		8	- 8	8	0	0	9	9
Pinnotheridae sp. Indet. (larvae)	0	0	0	0		0	0	0	0	1	9	1
Fabia subquadrata	8	8	1	8		1	0	0	2	1	8	3
Pinnixa cf. schmitti	1	1	4	5		8	4	3	5	5	9	14
Insecta sp. Indet.	•	0	0	0		0	0	0	0	9	V	Ø
Diptera I sp. Indet.	0	0	6	8		9	9	8	0	9	9	
Chironomidae sp. Indet. (larvae)	V	ש	. 6	V			8	0	י		U	
Golfingia sp. Indet.	V	V	Ø			9	0		1 9	5	8	9
Golfingia minuta	9	•	V			9	9	0	V		v	
Echiuridae sp. Indet.		0	8	θ.		9			V	0	0	•
Phoronida sp. Indet.		8	0	0		9	8	V	V	0	<b>U</b>	10 10
Phoromopsis harmeri Bryozoa-Menipea sp. Indet.	Ø	0	<b>0</b>	<b>U</b>		•	۷	9		b 0	4	12
Bowerbankia gracilis	1	υ Δ	<b>U</b>	υ Δ			0		0	0	0	D A
Bryozoa-Cheilostomata-Anasca sp. Indet.	a	о О	0.	0 0		1	9	0	<b>v</b>	•	•	0
Bryozoa-Cheilostomata-Ascophora sp. Inde	. 0	0 A	0	<b>0</b>		9	9	0	υ Δ	υ 0	0	10 0
Terebratalia transversa	. 0	<b>u</b>	0	<b>a</b>		9	0	D A	4	7	7	
Goniasteridae sp. Indet.	•	1	υ 0	<b>0</b>			D A	<b>0</b>	. I	, a	, A	15
Solasteridae sp. Indet.	Δ	1	Δ	1		2	•	5	•	7	9	. 10
Ophiura lutkeni	0	, i	Δ			<u> </u>	<u>.</u>		1		0 0	. 10
Amphiodia urtica	<u> </u>	<b>0</b>	2	a		9	4	<b>0</b>	4	a	•	1
Strongylocentrotus sp. Indet.	4			•	•	_	<b>6</b>	0	<b>0</b>		1 0	
Holothuroidea sp. Indet.	á	9	0	0		0	0	0	ď Á	0	0	0
Phyllophoridae sp. Indet.	4	υ Δ	0 0	0		4	0	<b>U</b>	Δ		0	t t
Cucumaria piperata	4	0 A	0 0	a				0	0	U.	<b>u</b>	
Cucumaria sp. 2 Indet.	Δ.	<b>0</b>	<b>v</b>	Δ		9	1	1	υ Δ	0	a	1
Cucumaria sp. 1 Indet.	1	2	0 0	Δ		* * * * * * * * * * * * * * * * * * *	•	1	. g	1	. 0	
Eupentacta sp. Indet.	à	с 0	a	Δ.		a a	•	3	£	1	<u> </u>	a
Eupentacta pseudoquinquesemita	1	0	1	<b>a</b>		9	a	Δ	<b>0</b>	<b>a</b>	a	<u> </u>
Pentamera sp. Indet.	à	<u>a</u>		. a		•	0	υ Δ	2	7	, , ο	5
Pentamera populifera	a	ä		a		ø	a	2	a	6	a	5
Leptosynapta sp. Indet.	•	a	a	à		a	· a	Δ	Q	a	. 0	a
Clavelinidae sp. Indet.	a	a	a	a		a	a	a	a	a	a	a
Misc. (?Ascidian)	<u> </u>	<u>a</u>	a	a		9	9		A	a	a	9
Stolidobranchia sp. Indet.	۵	8	0	a	1	a	·a	a	2	a	a	2
Mogulidae sp. Indet. (larvae)	a	ū	0	a		o o	. 0	, a	Δ	a	D	0
Mogula sp. Indet: (Tarvaer	a	8	2	Ď,		. 2	ρ	0	A	a	0	a
Odontopyxis trispinosa	Ø.	9	0	۵		<u>.</u>	Ω	9	a	a	a	a
Unidentified egg	a	0	0	a		Δ	A	0	P	3	6	9
ansenesisen Egg	U	v	·	•		U	U	U			3	•

ASARCO RAW BIOLOGICAL DATA			• •								•	
TAXON NAME	T4-2-A	T4-2-B	T4-2-C	T4-2-D	T4-2-E	T4-2-TOT	T6-3-A	T6-3-B	T6-3-C	T6-3-D	T6-3-E	T6-3-TOT
Cancer productus	8	8	0	0	0	0	9	 0	<u>-</u>	0	8	0
Lophopanopeus (megalops)	8	8	0	0	0	0	9	9	9	0	8	8
Lophopanopeus bellus (larvae & adult)	1	2	9	5	0	8	0	0	0	1	0	1
Pinnotheridae sp. Indet. (larvae)	4	8	1	8	9	22	2	4	1	2	8	9
Fabia subquadrata	0	0	8	Q	0	0	9	0	•	0	8	0
Pinnixa cf. schwitti	14	58	96	102	114	384	56	51	31	16	2	156
Insecta sp. Indet.	0	8	0	8	0	0	8	8	0	8	0	0
Diptera I sp. Indet.	9	8	8	•	8	9	0	0	8	0	0	9
Chironomidae sp. Indet. (larvae)	8	8	8		8	8	8	0	0	8	8	8
Golfingia sp. Indet.	4	3	2	5	2	16	0	3	0	1	9	4
Golfingia minuta	8	8	0	0	0	0	0	8	8	. 6	8	0
Echiuridae sp. Indet.	8	0	8	8	5	5	1	2	1	1	0	5
Phoronida sp. Indet.	8	0	0	9	8	0	0	8	0	0	8	8
Phoronopsis harmeri	1	1	1	1	1	5	8	6.	0	0	8	0
Bryozoa-Menipea sp. Indet.	6	0	2	8	0	8	0	0	8	0	0	0
Bowerbankia gracilis	0	9	2	5	0	4	0	0	9	0	0	9
Bryozoa-Cheilostomata-Anasca sp. Indet.	12	5	1	18	33	69	5	25	2	3	0	32
Bryozoa-Cheilostomata-Ascophora sp. Inde	. 0	8	8	8	0	0	9	6	1	0	. 8	1
Terebratalia transversa	1	0	1	0	2	4	8	2	· 3	1	0	6
Goniasteridae sp. Indet.	1	2	8	0	3	6	8	0	0	0	9	Ģ
Solasteridae sp. Indet.	8	8	0	0	0	0	2	1	2	0	; <b>8</b>	5
Ophiura lutkeni	7	13	18	17	8	63	5	1	6	2	8	11
Amphiodia urtica	0	0	0	8	1	1	0	0	0	8	0	0
Strongylocentrotus sp. Indet.	8	0	9	8	9	0	0	9	1	0	0	1
Holothuroidea sp. Indet.	1	2	8	3	8	6	0	0	0	0	1	1
Phyllophoridae sp. Indet.	0	8	8	0	Ģ	0	0	0	0	9	0	0
Cucumaria piperata	8	8	0	8	0	0	16	13	1	13	9	43
Cucumaria sp. 2 Indet.	0	0	0	8	ø	0	. 9	8	8	0	0	0
Cucumaria sp. 1 Indet.	8	. 0	0	0	8	0	0	0	0	0	0	8
Eupentacta sp. Indet.	8	21	20	3	4	48	0	0	0	0	0	0
Eupentacta pseudoquinquesemita	5	3	7	6	3	24	3	2	3	1	0	9
Pentamera sp. Indet.	0	0	Ø	0	0	8	0	ð	0	8	0	0
Pentamera populifera	0	0	0	0	0	0	0	. 2	1	0	0	3
Leptosynapta sp. Indet.	0	1	0	0	0	1	0	8	9	0	0	2
Clavelinidae sp. Indet.	5	3	0	1	3	12	8	0	. 0	0	0	8
Misc. (?Ascidian)	0	Ø	0	0	0	0	0	0	0	Ø	0	0
Stolidobranchia sp. Indet.	8	1	0	0	0	1	8	9	0	0	0	0
Mogulidae sp. Indet. (larvae)	9	0	0	9	0	0	8	0	1	1	9	2
Mogula sp. Indet.	1	0	0	0	0	1	0	8	. 0	0	Ø	8
Odontopyxis trispinosa	0	0	ð	8	0	0	0	. 8	0	0	0	0
Unidentified egg	8	8	0	6	0	0	0	0	0	2	0	2

ASARCO RAW BIOLOGICAL DATA	<b>TO</b> 4 O	T0 / 0	T		<b>TO</b> / F	-0 / -O-	<b>710.1.0</b>	T10 1 D	710 1 5	740 4 B	<b>740 4 5</b>	T10 1 70T
TAXON NAME	T8-4-A	T8-4-8	T8-4-C	T8-4-D	T8-4-E	78-4-TOT	T10-1-A	T10-1-B	T10-1-C	T10-1-D	110-1-6	T10-1-TOT
Cancer productus	8	9	0		0	0	0	0	9	1	0	1
Lophoparopeus (megalops)	0	0	0	0	0	8	0	0	9	0	9	0
Lophopanopeus bellus (larvae & adult)	1	0	0	0	0	1	0	0	9	1	0	· 1
Pinnotheridae sp. Indet. (larvae)	9	8	9	. 8	8	0	0	0	0	0	0	0
Fabia subquadrata	8	8	i	0	0	1	9	0	0	0	0	0
Pinnixa cf. schwitti	12	14	12	3	11	52	4	5	5	2	3	13
Insecta sp. Indet.	0	0	0	8	0	8	0	0	8	. 0	0	9
Diptera I sp. Indet.	0	0	0	8	8	8	0	8	0	0	9	0
Chironomidae sp. Indet. (larvae)	0	8	0	0	8	0	8	0	0	0	0	0
Golfingia sp. Indet.	0	5	1	0	1	4	. 0	0	8	0	0	0
Golfingia minuta	2	4	0	5	2	13	0	Ø	0	0	0	0
Echiuridae sp. Indet.	8	0	0	9	9	0	8	6	0	8	8	0
Phoronida sp. Indet.	8	0	0	9	1	1	8	0	. 9	0	9	9
Phoronopsis harmeri	Ø	8	1	0	0	1	8	9	0	0	•	9
Bryozoa-Menipea sp. Indet.	0	4	1	4	0	9	0	0	0	8	0	8
Bowerbankia gracilis	15	56	23	5	18	87	0	8	0	0	0	8
Bryozoa-Cheilostomata-Anasca sp. Indet.	0	0	2	. 0	2	4	9	0	. 0	0	0	8
Bryozoa-Cheilostomata-Ascophora sp. Inde	. 0	31	12	13	14	70	9	0	0	0	9	9
Terebratalia transversa	0	0	0	0	8	0	0	0	0	0	0	0
Goniasteridae sp. Indet.	0	0	1	8	9	1	1	0	9	0	0	1
Solasteridae sp. Indet.	. 0	2	1	0	2	5	19	21	6	3	9	58
Ophiura lutkeni	. 0	0	2	0	8	5	0	0	0	0	0	0
Amphiodia urtica	4	7	5	4	5	25	2	1	0	0	0	3
Strongylocentrotus sp. Indet.	9	0	0	8	8	0	0	8	0	0	0	0
Holothuroidea sp. Indet.	0	0	1	2	0	3	1	0	0	0	0	1
Phyllophoridae sp. Indet.	10	16	9	1	12	48	5	1	1	5	8	6
Cucumaria piperata	0	2	0	0	. 0	2	0	0	0	0	. 0	0
Cucumaria sp. 2 Indet.	0	3	0	8	0	3	0	8	0	4	1	5
Cucumaria sp. 1 Indet.	20	32	23	24	43	142	0	0	. 0	. 0	0	0
Eupentacta sp. Indet.	0	. 0	ø	9	3	3	0	0	0	8	9	0
Eupentacta pseudoquinquesemita	1	5	0	9	0	6	0	0	0 '	0	0	0
Pentamera sp. Indet.	0	0	. 0	0	9	9	9	0	9	9	0	0
Pentamera populifera	0	0	0	1	9	1	1	5	0	8	1	7
Leptosynapta sp. Indet.	0	0	0	1	0	1	9	0	0	0	0	0
Clavelinidae sp. Indet.	8	21	0	1	2	32	0	0	0	8	0	0
Misc. (?Ascidian)	0	0	0	0	. 0	0	8	0	8	8	1	1
Stolidobranchia sp. Indet.	9	ž	0	1	4	7	0	. 0	0	0	0	. 0
Mogulidae sp. Indet. (larvae)	0	5	0	0 -	. 0	5	9		0	. 0	0	0
Mogula sp. Indet.	0	0	0	4	8	4		8	0	. 0	0	. 0
Odontopyxis trispinosa	0	0	0	9	8	9	8 .	0	0	0	0	0
Unidentified egg	0	5	0	0	9	5	0.	0	0	0	0	. 8

TAXON NAME T11-7-A T11-7-B T11-7-C T11-7-D T11-7-E T11-7-TOT T12-1-A T12-1-B T12-1-C T12-1-D T12-1	E T12-1-TOT
Cancer productus 8 8 8 8 8 8 8 9 9	a a
Lophopanopeus (Megalops) 8 0 0 0 0 0 0 0 0	9 9
Lophopanopeus bellus (larvae & adult) 0 0 0 0 0 0 0 0 0	a a
Pinnotheridae sp. Indet. (larvae) 0 1 0 0 0 1 0 3 0 2	a 5
Fabia subquadrata 8 0 0 0 0 0 0 0 0	0 0
Pinnixa cf. schmitti 0 3 0 2 1 6 5 14 16 22	0 67
Insecta sp. Indet. 0 0 0 0 0 0 0 0	0 0
Diptera I sp. Indet. 0 0 0 0 0 0 0 0	0 0
Chironomidae sp. Indet. (larvae) 8 0 0 0 0 0 0	0 0
Golfingia sp. Indet. 0 0 0 0 0 0 0 0	0 0
Golfingia minuta 8 0 0 0 0 0 0 0	0 0
Echiuridae sp. Indet. 8 8 8 8 8 8 8	0 0
Phoronida sp. Indet. 8 8 8 8 8 8 8 8 8 8	0 0
Phoronopsis harmeri 0 0 0 0 0 0 0 0	0 0
Bryozoa-Menipea sp. Indet. 8 8 8 8 4 4 8 8 8 8	0 0
Bowerbankia gracilis 0 0 0 0 0 0 0	8 8
Bryozoa-Cheilostowata-Anasca sp. Indet. 0 0 0 0 0 0 0 0	0 0
Bryozoa-Cheilostomata-Ascophora sp. Inde 0 0 0 0 0 0 0 0	0 0
Terebratalia transversa 0 0 0 0 0 0 0 0	0 0
Soniasteridae sp. Indet. 0 1 0 0 0 1 0 0 0	0 6
Solasteridae sp. Indet. 8 0 0 0 0 0 0 0 0	0 0
Ophiura lutkeni 0 0 0 0 0 0	1 1
Amphiodia urtica 9 0 8 8 8 0 0 0 6	0 0
Strongylocentrotus sp. Indet. 0 0 0 0 0 0 0 0	0 0
Holothuroidea sp. Indet. 0 0 0 0 0 1 0 0 0	0. 1
Phyllophoridae sp. Indet. 8 8 8 8 8 8 8 8	0 0
Cucumaria piperata 0 0 0 0 0 0 0 0 0	0 0
Cucumaria sp. 2 Indet. 0 0 0 0 0 1 0 0 0	0 1
Cucumaria sp. 1 Indet. 0 0 0 0 0 0 0 0	0 0
Eupentacta sp. Indet. 0 0 0 0 9 9 9 0 0 0	0
Eupentacta pseudoquinquesemita 0 0 0 0 0 0 0 0	0 0
Pentamera sp. Indet. 8 8 8 9 8 8 8 8 8	0 0
Pentamera populifera 0 0 0 0 1 1 0 0 0 0	0
Leptosynapta sp. Indet. 0 0 0 0 0 0 0 0 0	0 0
Clavelinidae sp. Indet. 8 0 0 0 0 0 0 0 0	8 8
Misc. (?Ascidian)	0 0
Stolidobranchia sp. Indet. 0 0 0 0 0 0 0 0 0	0 0
Mogulidae sp. Indet. (larvae) 0 0 0 0 0 0 0 0	9 0
Mogula sp. Indet. 8 8 8 0 0 0 0 0 0 0	0
Odontopyxis trispinosa 8 8 8 8 8 8 8 8	0 0
Unidentified egg 0 0 0 0 0 0 0 0 0	0

ASARCO RAM BIOLOGICAL DATA TAXON NAME	T16-1-A	T16-1-9	T16-1-C	T16-1-D	T16-1-E	T16-1-TOT	T16-4-A	T16-4-B	T16-4-C	T16-4-D	T16~4~E	T16-4-TOT
·····												
Cancer productus	9	9	8	0	0	9	0	9	8	0	0	9
Lophoparopeus (megalops)	0	0	0	0	6	0	9	0	0	9	0	0
Lophopanopeus bellus (larvae & adult)	8	8	0	8	8	8	0	8	8	0	0	. 8
Pinnotheridae sp. Indet. (larvae)	3	0	1	8	8	4	0	1	0	9	6	1
Fabia subquadrata	0	0	0	0	8	0	, <b>0</b>	0	. 0	0	0	0
Pinnixa cf. schmitti	27	16	14	7	10	74	3	5	5	5	1	10
Insecta sp. Indet.	0	. 0	0	0	0	0	0	0	0	0	0	0
Diptera I sp. Indet.	0	0	0	0	9	0	9	1	9	0	0	1
Chironomidae sp. Indet. (larvae)	0	8	8	8	8	9	8	8	8	8	8	0
Golfingia sp. Indet.	0	0	0	8	0	. 0	9	0	0	. 0	0	0
Golfingia minuta	0	0	8	8	8	0	2	1	8	1	. 1	5
Echiuridae sp. Indet.	8	1	0	0	9	1	0	1	0	0	8	1
Phoronida sp. Indet.	0	0	8	0	8	0	0	8	0	0	0	0
Phoronopsis harmeri	8	8	1	9	5	3	8	9	0	9	9	9
Bryozoa-Menipea sp. Indet.	0	0	0	8	0	0	0	0	9	0	8	0
Bowerbankia gracilis	0	2	1	5	0	5	8	8	1	. 6	. 0	1
Bryozoa-Cheilostomata-Anasca sp. Indet.	. é	0	8	8	8	8	0	8	8	0	0	0
Bryozoa-Cheilostomata-Ascophora sp. In	de 0	0	0	0	0	0	0	1	. 0	. 0	1	5
Terebratalia transversa	0	1	0	1	2	4	9	0	0	0	0	0
Goniasteridae sp. Indet.	0	0	0	0	8	9	0	0	0	•	0	8
Solasteridae sp. Indet.	9	0	0	0	9	9	0	0	<b>9</b> ·	0	0	9
Ophiura lutkeni	8	9	9	9	0	9	9	9	0	0	9	9
Amphiodia urtica	8	0	9	0	2	5	0	0	8	0	. 0	0
Strongylocentrotus sp. Indet.	8	0	8	0	0	Ø	8	0	0	9	0	8
Holothuroidea sp. Indet.	0	0	1	8	0	1	1	0	1	0	8	2
Phyllophoridae sp. Indet.	8	0	0	9	0	0	8	8		0	0	9
Cucumaria piperata	8	9	8	. 0	8	0	0	0	0	. 0	8	0
Cucumaria sp. 2 Indet.	6	0	0	0	0	9	4	10	3	4	. 3	24
Cucumaria sp. 1 Indet.	3	4	4	2	6	19	0	0	0	0	0	9
Eupentacta sp. Indet.	0	0	8	9	9	0	. 0	9	0	8	8	0
Eupentacta pseudoquinquesemita	0	0	0	0	0	0	8	9	9	0	0	0
Pentamera sp. Indet.	0	0	0	0	. 0	0	1	1	i 1	i 1 0	; 2	5
Pentamera populifera	8	9	0	8	0	9	9	0.	9	8	. 0	8
Leptosynapta sp. Indet.	0	0	9	0	0	0	8	0'	. 0	0	0	0
Clavelinidae sp. Indet.	0	0	9	0	0	0	0	9	9	0	. 0	0
Misc. (?Ascidian)		0	6	0	0	0	0	0	0	0	0	0
Stolidobranchia sp. Indet.	0	0	0	0	0	9	0	8	0	0	0	. 0
Mogulidae sp. Indet. (larvae)	0	2	0	0	0	2	0	. 8		0	0	0
Mogula sp. Indet.	0	0	0	8	.6		ø	0	0	0	0	
Odontopyxis trispinosa	0	Ø	0	0		-	ō	0	0	0	0	0
Unidentified egg	17	12	14	10	13		0	8	0	9	Ø	8

ASARCO RAW BIOLOGICAL DATA TAXON NAME	T22-1-A	T22-1-B	T22-1-C	T22-1 <b>-D</b>	722-1-E	T22-1-TOT	T22-2-A	T22-2-B	T22-2-C	T22-2-D	155-5-€	T22-2-TOT		GRAND FOTAL
Cancer productus	0	8	0	0	8	0	0	ø	0	0	0	9	1	1
Lophopanopeus (megalops)	0	0	0	1	3	4	8	0	8	8	0	0	j	4
Lophopanopeus bellus (larvae & adult)	7	3	9	7	11	37	0	1	Ø	8	1	2	1	50
Pinnotheridae sp. Indet. (larvae)	8	9	0	9	9	0	1	0	0	Ø	0	1	1	44
Fabia subquadrata	0	0	8	8	9	0	0	0	8	0	9	8	ł	5
Pinnixa cf. schwitti	8	3	2	4	2	19	21	В	42	6	14	91	1	894
Insecta sp. Indet.	8	0	1	9	8	1	0	0	9	9	9	8	1	1
Diptera I sp. Indet.	0	. 0	. 0	0	8	0	0	Ø	8	9	0	8	1	1
Chironomidae sp. Indet. (larvae)	1	9	1	9	9	2	0	0	2	1	9	3	1	5
Golfingia sp. Indet.	9	8	8	0	9	9	0	9	9	0	8	8	1	33
Golfingia winuta	2	1	5	1	6	15	8	9	8	0	0	0	ı	33
Echiuridae sp. Indet.	8	9	0	9	9		0	9	8	9		9	1	9
Phoronida sp. Indet.	0	0	9	8	3	. 3	9	1	0	0	0	1	10	5
Phoronopsis harweri	8	0	8	8	8	. 0	0	0	9	8	0	0	ł	21
Bryozoa-Menipea sp. Indet.	8	8	9	8	8	8	9	9	9	8	9	8	1	21
Bowerbankia gracilis	9	8	9	9	8	0	6	9	5	3	4	15	1	113
Bryozoa-Cheilostomata-Amasca sp. Indet.	0	8	8	. 6	0	0	9	9	9	9	9	9	1	105
Bryozoa-Cheilostomata-Ascophora sp. Inde	. 0	1	2	1	1	5	5	8	2	1	8	5	ı	83
Terebratalia transversa	0	8	8	8	8	8	0	9	0	0	0	8	1	29
Goniasteridae sp. Indet.	8	6	8	8	0	8	5	0	1	2	5	7	i	17
Solasteridae sp. Indet.	8	0	0	8	8	0	8	8	9	9	0	0	ı	80
Ophiura lutkeni	8	1	. 0	0	8	1	0	0	0	.8	8	0	ı	78
Amphiodia urtica	1	3	1	1	1	7	5	3	0	, , 2	3	10	Ł	51
Strongylocentrotus sp. Indet.	6	0	8		0	0	0	0	0	,	0	0	1	i
Holothuroidea sp. Indet.	9	1	2	8	8	3	8	8	5	1	1	12	i	30
Phyllophoridae sp. Indet.	0	0	8	0	8	0	0	5	8	8	0	5	ı	68
Cucumaria piperata	0	1	5	0	1	4	8	1	. 0	0		1	İ	51
Cucumaria sp. 2 Indet.	8	0	Ø	8	0	0	0	1	8	5	8	. 6	1	46
Cucumaria sp. 1 Indet.	0	8	8	8	0	0	10	2	4	5	3	24	i	194
Eupentacta sp. Indet.	8	0	8	0	0	0	0	0	0	8	8	8	ţ	60
Eupentacta pseudoquinquesemita	1	0	0	0	0	1	0	Ø	0	2	3	5	1	47
Pentamera sp. Indet.	0	0	0	8	0	0	0	0	0	0	8	Ø	i	10
Pentamera populifera	8	0	0	8	0	ø	5	1	9	1	5	9	i	27
Leptosynapta sp. Indet.	Ø	0	0	Ø	8	0	3	ø	0	5	3	8	į	10
Clavelinidae sp. Indet.	. 0	0	8	0	0	ø	0	0	6	9	8	Ø	i	44
Misc. (?Ascidian)	0	0	0	3	0	0	8	0	8	i	0	1	ļ	2
Stolidobranchia sp. Indet.	0	0	0	0	0	0	0	e	8	ø	8	0	j	10
Mogulidae sp. Indet. (larvae)	0	0	0	0	0	0	Ø	8	8	0.	0	0	i	9
Mogula sp. Indet.	Ø	0	Ø	8	0	0	0	0	ð	0	0	0	i	7
Odontopyxis trispinosa	0	0	1	8	6	1	Ø	8	0	0	0	0	i	1
Unidentified egg	0	0	0	0	0	9	0	0	0	8	8	0	1	82

IMMATURE FORMS COLLECTED	NODC	T2-5-TOT	MEAN	STD	T3-5-TOT	MEAN	STD	T4-2-TOT	MEAN	STD
Synidotea sp. Indet. (juvenile)	6162020200	0	0.000	0.000	8	0.000	0.000		6.000	9.000
Melita sp. Indet. (juvenile)	6169211000	0	<b>e.</b> 000	0.000	0	9.000	0.000	9	0.000	9.000
Hyperiidea sp. Indet. (juvenile)	6170000000	0	0.000	0.008	0	0.000	0.000	0	9.000	0.000
Hyperiidae sp. Indet. (juvenile)	6170010000	0	0.000	0.000	0	0.000	0.000	8	0.000	0.000
Callianassa sp. Indet. (juvenile)	6183040200	0	0.000	0.008	Ø	0.000	0.000	8	0.000	0.000
Brachyura sp. Indet. (larvae)	6184000000	0	0.000	0.000	. 0	0.000	0.000	8	0.000	9. 999
Cancer sp. Indet. (larvae & juvenile)	6188030100	0	0.000	0.000	0	0.000	0.000	11	2.200	0.748
Lophopanopeus (megalops)	6189020100	0	0.000	8.000	0	0.000	0.000	8	0.000	0.000
Lophopanopeus bellus (larvae & adult)	6189020101	0	0.000	0.000	0	0.000	0.000	8	1.600	1.855
Pinnotheridae sp. Indet. (larvae)	6189060000	0	0.000	9.000	1	0.200	0.400	22	4.400	3.611
Goniasteridae sp. Indet.	8111040000	1	0.250	0.433	0	0.000	0.000	6	1.200	1.166
Solasteridae sp. Indet.	8113010000	2	<b>0.</b> 500	0.500	10	2.000	1.789	8	0.000	0.000
Holothuroidea sp. Indet.	8170000000	0	0.000	0.000	0	0.000	0.000	6	1.200	1.166
Phyllophoridae sp. Indet.	8172040800	0	0.000	9.000	1	0.200	0.400	Ó	0.000	0.000
Cucumaria sp. 2 Indet.	8172060198	0	0.000	0.000	1	0.200	<b>8.</b> 400	0	0.000	0.000
Cucumaria sp. 1 Indet.	8172060199	3	0.750	0.829	6	1.200	<b>6.</b> 748	. 0	0.000	0.000
Eupentacta sp. Indet.	8172060200	0	0.000	0.000	0	9.000	0.000	48	9.600	9.002
Pentamera sp. Indet.	8172050300	0	0.000	0.000	5	1.000	1.265	9	0.000	0.000
Leptosynapta sp. Indet.	8178010200	8	0.000	9.000	8	0.008	9.000	1	0.200	0.400
Clavelinidae sp. Indet.	8403010000	0	0.000	0.000	9	0.000	0.000	12	2.400	1.744
Mogulidae sp. Indet. (larvae)	8406030000	0	0.000	0.000	.0	0.000	0.000		0.000	0.000
TOTAL		6.00	1.50	1.76	24.00	4.80	5. 00	114.00	22.80	19.69
SIMPSON'S INDEX =			0.042	0.009		0.044	0.013		<b>0.</b> 102	0.018
SHANNON-WIENER INDEX =			3. 333	<b>0.</b> 141		3.415	0.351		3. 153	0. 101

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IMMATURE FORMS COLLECTED	NODC	T6-3-TOT	MEAN	STD	T8-4-TOT	MEAN	STD	T10-1-TOT	MEAN	STD
Symidotea sp. Indet. (juvenile)	6162020200	0	9. 999	0.000	9	0.000	0.000	9	0.000	0.000
Melita sp. Indet. (juvenile)	6169211000	9	8.000	0.000	0	9.000	0.000	8	0.000	0.800
Hyperiidea sp. Indet. (juvenile)	6170000000	8	8.000	8.680	0	0.000	0.000	9	0.000	0.000
Hyperiidae sp. Indet. (juvenile)	6170010000	0	0.000	0.000	1	0.200	0.400	8	0.000	6.000
Callianassa sp. Indet. (juvenile)	6183040200	0	0.000	0.000	4	0.800	0.980	0	8.000	<b>8.</b> 008
Brachyura sp. Indet. (larvae)	6184000000	0	0.000	0.000	0	0.000	0.000	0	8.000	0.000
Cancer sp. Indet. (larvae & juvenile)	6188030100	5	1.000	1.095	1	0.200	0.400	. 0	0.000	0.000
Lophopanopeus (megalops)	6189020100	0	0.000	0.000	7	1.400	1.497	0	<b>6. 9 0 0</b>	0.000
ophopamopeus bellus (larvae & adult)	6189020101	1	0.200	8.480	0	0.000	9.000	6	9.000	0.000
innotheridae sp. Indet. (larvae)	6189060000	9	1.800	1.327	. 0	0.000	9.000	3	9.600	0.800
oniasteridae sp. Indet.	8111040000	8	9.000	9.000	8	9.000	0.000	ø	0.008	0.000
olasteridae sp. Indet.	8113010000	5	1.000	0.894	8	0.000	0.000	0	0.000	0.000
olothuroidea sp. Indet.	8170000000	1	0.200	0.400	1	0.200	0.400	0	0.000	0.000
nyllophoridae sp. Indet.	8172040000	0	0.000	9.000	5	0.400	0.490	9	0.000	0.608
cumaria sp. 2 Indet.	8172050198	8	0.000	0.000	1	0.200	0.400	9	0.000	0.000
cumaria sp. 1 Indet.	8172060199	8	0.000	0.000	9	9.000	0.000	0	0.000	0.000
upentacta sp. Indet.	8172060200	0	0.000	0.000	1	0.200	0.400	0	9.000	0.000
entamera sp. Indet.	8172060300	0	<b>8.600</b>	8.000	1	0.200	0.400	9	0.000	0.000
eptosynapta sp. Indet.	8178919299	0	0.000	9.000	0	0.000	0.000	0	0.000	0.000
lavelinidae sp. Indet.	8403010000	0	9.000	0.000	0	9.000	0.000	3	0.600	1.200
ogulidae sp. Indet. (larvae)	8406030000	2	0.400	0.498	0	6.000	<b>0.</b> 000	8	0.000	0.000
TOTAL		23.00	4.60	4.61	19.00	3.80	5.37	6.80	1.20	2.00
SIMPSON'S INDEX =			0.053	0.028		0.030	0.004		<b>0.0</b> 72	0.011
SHANNON-HIENER INDEX =			3. 759	0.242		3.967	0.073		3. 153	<b>0.</b> 165

IMMATURE FORMS COLLECTED	NODC	T11-7-TOT	MEAN	STD	T12-1-TOT	MEAN	STD	T16-1-TOT	MEAN	STD
Synidotea sp. Indet. (juvenile)	6162020200	0	0.000	0.000	8	0. 000	0.000	1	8.200	0.400
Melita sp. Indet. (juvenile)	6169211000	0	9.000	0.000	8	0.000	0.000	0	6.000	0.600
Hyperiidea sp. Indet. (juvenile)	6170000000	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000
Hyperiidae sp. Indet. (juvenile)	6170010000	0	0.000	0.000	0	0.080	0.000	9	1.800	1.720
Callianassa sp. Indet. (juvenile)	6183040200	2	0.400	0.490	0	0.000	9.000	11	2.200	1.720
Brachyura sp. Indet. (larvae)	6184000000	0	0.000	0.000	0	9.000	0.000	0	0.000	0.000
Cancer sp. Indet. (larvae & juvenile)	6188030100	0	9.000	0.000	0	0.000	0. 00 <del>0</del>	9	9.000	0.000
Lophopanopeus (megalops)	6189020100	0	<b>8.</b> 008	8.006	0	0.000	6.606	8	0.000	0.000
Lophopanopeus bellus (larvae & adult)	6189020101	0	0.000	0.000	9	9. 648	0.000	0	0.000	9.000
Pinnotheridae sp. Indet. (larvae)	6189060000	0	9.000	0.000	. 0	0.000	0.000	0	0.000	6.666
Goniasteridae sp. Indet.	8111040000	9	0.000	0.000	0	0.000	0.000	9	9.000	0.000
Solasteridae sp. Indet.	8113010000	0	0.000	0.000	0	0.000	0.000	9	0.000	0.000
Holothuroidea sp. Indet.	8170000000	0	0.000	0.000	9	0.000	0.000	9	0.000	0.000
Phyllophoridae sp. Indet.	8172040000	0	0.080	0.000	9	9.000	9.000	1	0.200	0.400
Cucumaria sp. 2 Indet.	8172060198	0	0.080	0.000	9	9.000	0.000	0	0.000	0.000
Cucumaria sp. 1 Indet.	8172060199	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000
Eupentacta sp. Indet.	8172060208	9	0.000	9.999	0	9.000	0.000	0	0.000	8.000
Pentamera sp. Indet.	8172050300	0	0.000	9.000	0	0.000	0.000	0 .	9.000	0.000
Leptosynapta sp. Indet.	8178010200	8	0.000	0.000	8	0.000	0.000	0	9. 000	0.000
Clavelinidae sp. Indet.	8403010000	9	0.000	0.000	. 9	6.000	9.000	0	9.000	0.000
Mogulidae sp. Indet. (larvae)	8406030000	9	9. 000	9.000	0	0.000	0.000	0	0.000	9. 999
TOTAL		2.00	0.48	0.49	0.00	0.00	0.00	22.60	4.49	4.24
SIMPSON'S INDEX =			0.037	0.032		0.523	<b>0.</b> 3 <b>8</b> 2		<b>0.0</b> 80	0.012
SHANNON-WIENER INDEX =			2.775	<b>0.</b> 386		1.388	0.853		3.311	0.107

(4.4)

IMMATURE FORMS COLLECTED	NDDC	T16-4-TOT	MEAN	STD	T22-1-TOT	MEAN	STD	T22-2-TOT	MEAN	STD
Synidotea sp. Indet. (juvenile)	6162020208	0	0.000	0.000	0	0.000	0.000	8	<b>9.000</b>	0.000
Melita sp. Indet. (juvenile)	6169211000	0.	0.000	9.000	Ø	0.600	0.000	0	0.000	0.000
Hyperiidea sp. Indet. (juvenile)	6170000000	8	9. 998	8.689	0	0.000	0.000	1	0.200	0.400
Hyperiidae sp. Indet. (juvenile)	6170010000	0	0.000	0.000	0	0.000	0.000	1	0.200	0.400
Callianassa sp. Indet. (juvenile)	6183848288	0	9.000	9.000	0	0.000	9.000	0	9.000	9.000
Brachyura sp. Indet. (larvae)	6184000000	5	<b>0.</b> 400	<b>0.</b> 800	1	0.200	0.480	0	9.000	0.000
Cancer sp. Indet. (larvae & juvenile)	6188939198	8	0.000	0.000	45	9.000	3. 588	13	2.600	1.020
Lophopanopeus (megalops)	6189020100	9	0.000	9. 999	. 4	9.800	1.166	9	9.000	0.000
Lophopanopeus bellus (larvae & adult)	6189020101	0	0.000	0.000	37	7.400	2.653	2	<b>0.</b> 400	<b>8.</b> 498
Pinnotheridae sp. Indet. (larvae)	6189060000	1	0.200	0.400	0	0.000	9.000	1	9.200	0.400
Goniasteridae sp. Indet.	8111046000	0	0.000	0.000	0	9.999	0.000	7	1.488	0.800
Solasteridae sp. Indet.	8113010000	0	0.000	0.000	9	0.000	0.000	0	0.000	0.000
Holothuroidea sp. Indet.	8170000000	2	<b>0.</b> 400	<b>0.</b> 498	3	0.600	0.800	12	2.400	2.871
Phyllophoridae sp. Indet.	8172040000	8	0.000	9.000	0	9. 909	0.000	5	1.000	2.000
Cucumaria sp. 2 Indet.	8172050198	24	4.800	2.638	0	0.000	0.000	6.	1.200	1.939
Cucumaria sp. 1 Indet.	8172060199	8	0.000	0.600	0	0.000	8.000	24	4.800	2.786
Eupentacta sp. Indet.	8172060200	0	0.000	0.000	0	0.000	9.000	0	0.000	0.000
Pentamera sp. Indet.	8172060300	5	1.000	0.632	9	0.000	0.000	8	0.000	0.000
Leptosynapta sp. Indet.	8178010200	0	0.000	0.000	0	0.000	9.000	8	1.600	1.356
Clavelinidae sp. Indet.	8403010000	6	9.008	0.000	0	0.000	0.000	8	0. 800	0.000
Mogulidae sp. Indet. (larvae)	8486038808	0	9. 999	0.000	0	0.000	9.000	. 0	6. 000	0.000
TOTAL		34.00	6.80	4.96	90.00	18.00	8.71	80.00	16.00	14.46
SIMPSON'S INDEX =		•	0.060	0.026		<b>0.0</b> 65	0.021		<b>0.0</b> 68	0.011
SHANNON-HIENER INDEX =		·	3.329	0.267		3.512	0.205		3. 448	0.081

## BENTHIC BIOMASS DATA

# (Grams Per Sample)

GM3.000.000						
STATION	REPLICATE	ARTHROPODA	MOLLUSCA	ANNELIDA	MISC.	TOTAL
T2-5	A	0.1978	1.5875	0.6065	0.8281	3.2199
	В	0.1841	0.2084	1.4902	0.2794	2.1621
	C	0.1301	4.7081	0.6600	0.0803	5.5785
	D	0.0545	1.3347	0.0895	0.0191	1.4978
	E			MPLES TAKEN-		
	MEAN	0.1133	1.9597	0.7116	0.3017	3.1146
	STD	0.0758	1.6696	0.5017	0.3188	1.5495
						 2
T3-5	A	0.2124	1.9672	0.9801	0.2437	3.4034
	В	0.2395	2.7883	2.0339	0.4397	5.5014
	С	0.2390	6.2673	2.3626	0.3130	9.1819
	D	0.3170	6.5126	2.0388	1.0251	9.8935
	E	0.2063	1.0068	1.5498	0.4837	3.2466
	MEAN	0.2428	3.7084	1.7930	0.5010	6.2454
	STD	0.0395	2.2622	0.4823	0.2758	2.8126
T4-2	A	1.2318	1.6437	3.1795	10.4141	16.4691
	В	0.6211	1.3380	2.4857	6.1595	10.6043
	C	0.7686	0.8250	2.4958	3.1575	7.2469
	D	1.1946	1.6540	2.4789	4.5495	9.8770
	E	1.3683	1.7587	5.1007	6.4171	14.6448
	MEAN	1.0369	1.4439	3.1481	6.1395	11.7684
	STD	0.2890	0.3398	1.0125	2.4401	3.3391
T6-3	A	0.6175	1.5443	2.3689	1.6795	6.2102
	В	0.8878	6.6922	1.9374	3.3081	12.8255
	C	0.2979	2.9127	4.4615	0.8988	8.5709
	D	0.5952	2.6478	3.6171	3.5285	10.3886
	E	0.4075	0.9773	0.6122	0.1016	2.0986
	MEAN	0.5612	2.9549	2.5994	1.9033	8.0188
	STD	0.2020	1.9982	1.3374	1.3357	3.6700
T8-4	A	0.2518	2.1055	3.9631	2.5832	8.9036
	В	0.4595	2.0107	5.0121	3.3788	10.8611
•	С	0.6306	5.5979	3.8457	2.0460	12.1202
	D	0.2577	1.6816	3.8726	0.9092	6.7211
	E	0.2059	1.7486	2.8374	2.2572	7.0491
	MEAN	0.3611	2.6289	3.9062	2.2349	9.1310
	STD	0.1606	1.4929	0.6890	0.8029	2.1034

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#### BENTHIC BIOMASS DATA

# (Grams Per Sample)

STATION	REPLICATE	ARTHROPODA	MOLLUSCA	ANNELIDA	MISC.	TOTAL
T10-1	A B C D E MEAN STD	5.5099 1.1366 7.6206 3.4000 0.5947 3.6524 2.6435	0.4563 0.2654 0.1703 0.2497 0.2323 0.2748 0.0963	3.0397 1.8966 2.1666 1.8645 1.5979 2.1131 0.4971	0.1179 0.1557 0.1474 0.2640 0.1608 0.1692 0.0497	9.1238 3.4543 10.1049 5.7782 2.5857 6.2094 2.9858
T11-7	A B C D E MEAN STD	0.1160 1.0276 0.0995 0.1606 0.1060 0.3019 0.3635	1.6609 1.9307 1.8890 1.2767 4.1555 2.1826 1.0134	0.7469 2.4637 0.6087 1.1005 0.3314 1.0502 0.7489	0.0000 0.2089 0.0653 0.0000 0.1474 0.0843	2.5238 5.6309 2.6625 2.5378 4.7403 3.6191 1.3106
T12-1	A B C D E MEAN STD	0.1200 0.7360 0.3925 0.4773 0.3607 0.4173 0.1987	0.0046 0.1008 0.1380 0.0389 0.1034 0.0771	1.1748 0.7338 0.3746 1.0388 0.8516 0.8347 0.2755	0.0000 0.0000 0.1076 0.0431 0.0010 0.0303 0.0420	1.2994 1.5706 1.0127 1.5981 1.3167 1.3595 0.2132
T16-1	A B C D E MEAN STD	0.4982 0.2834 0.2799 0.3209 1.2252 0.5215 0.3608	1.7928 1.2781 1.6860 1.4343 3.1853 1.8753 0.6797	2.9419 1.4136 2.2554 1.2959 2.5349 2.0883 0.6386	0.6227 0.1854 0.1553 0.1983 0.2408 0.2805 0.1733	5.8556 3.1605 4.3766 3.2494 7.1862 4.7657 1.5540
T16-4	A B C D E MEAN STD	0.1524 0.1365 0.1272 0.0241 0.1764 0.1233 0.0523	0.9960 1.1990 0.8162 1.0053 0.4547 0.8942 0.2509	0.9614 1.2421 0.4678 1.4399 1.1134 1.0449	0.1462 0.1359 0.0580 0.1379 0.4690 0.1894 0.1434	2.2560 2.7135 1.4692 2.6072 2.2135 2.2519 0.4367

BENTHIC	BIOMASS D	ATA	(Grams Per	Sample)	. <del>-</del>	
STATION	REPLICATE	ARTHROPODA	MOLLUSCA	ANNELIDA	MISC.	TOTAL
T22-1	A	0.8131	0.7496	6.0413	0.3382	7.9422
	В	0.8037	1.1331	3.9596	1.1771	7.0735
	С	2.1887	1.5874	3.0126	0.6199	7.4086
_	<b>D</b>	0.8967	0.7130	2.4702	0.8522	4.9321
•	E	1.7674	0.5970	3.5865	1.1178	7.0687
	MEAN	1.2939	0.9560	3.8140	0.8210	6.8850
•	STD	0.5752	0.3635	1.2233	0.3129	1.0271
T22-2	: <b>A</b>	5.0269	1.7855	2.3656	0.6292	9.8072
	В	0.5522	1.8963	2.7507	0.7291	5.9283
	Č.	0.5938	1.2223	3.0554	0.8716	5.7431
	D.	3.8849	1.4516	2.1926	0.5005	8.0296
	Ē	0.7686	11.7254	2.9729	2.4727	17.9396
	MEAN	2.1653	3.6162	2.6674	1.0406	9.4896
•	STD	1.9062	4.0616	0.3368	0.7263	4.4800

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# **Final Report**

# ASARCO Tacoma Smelter Remedial Investigation

Volume 3 — Data Validation Reports

Parametrix, Inc. in Association with Hart Crowser

# ASARCO TACOMA SMELTER REMEDIAL INVESTIGATION

#### VOLUME III LABORATORY DATA VALIDATION

**MARCH 1989** 

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**HART-CROWSER** 

# TABLE OF CONTENTS

				Page
1.	INT	RODUCI	ΠΟΝ	. 1
2.	SUN	MARY	OF FINDINGS	. 5
	2.1		ICIAL SOIL	
		2.1.1	INORGANICS (PHASE I, TOTAL METALS)	. 6
		2.1.2	INORGANICS (PHASE I, EP TOXICITY METALS)	
		2.1.3	INORGANICS (PHASE II)	
		2.1.4	ORGANICS	
	2.2	SUBSU	URFACE SOIL OR SLAG	
		2.2.1	INORGANICS (PHASE I)	. 7
		2.2.2	INORGANICS (PHASE II)	. 7
		2.2.3	ORGANICS (PHASE I)	. 8
		2.2.4	ORGANICS (PHASE IÍ)	. 8
	2.3	GROU	JNDWATER	. 8
		2.3.1	INORGANICS (PHASE I)	. 8
		2.3.2	INORGANICS (PHASE II)	. 8
		2.3.3	ORGANICS (PHASE I)	. 9
		2.3.4	ORGANICS (PHASE II)	. 9
	2.4	FILL I	LEACHING INORGANICS	. 9
	2.5		ACE WATER	. 9
		2.5.1	INORGANICS	
		2.5.2	ORGANICS	. 10
	2.6	SURFI	CIAL MARINE SEDIMENT	. 10
		2.6.1	INORGANICS (PHASE I)	. 10
		2.6.2	INORGANICS (PHASE II, TOTAL METALS)	
		2.6.3	INORGANICS (PHASE II, EP TOXICITY METALS)	. 11
		2.6.4	ORGANICS (PHASE I)	. 11
		2.6.5	ORGANICS (PHASE II)	. 12
	2.7	MARI	NE SEDIMENT CORES	. 12
		2.7.1	INORGANICS	. 12
		2.7.2	ORGANICS	. 12
3.	LAB	ORATO	RY DATA VALIDATION	. 13
	3.1		CIAL SOIL INORGANICS (PHASE I, TOTAL METALS) .	
		3.1.1	ANALYTICAL METHODS	
		3.1.2	SAMPLE HANDLING	
		3.1.3	HOLDING TIMES	
		3.1.4	CALIBRATION	_
		3.1.5	BLANKS	14
		3.1.6	LABORATORY CONTROL SAMPLES	14
		3.1.7	DUPLICATE SAMPLE ANALYSIS	
		3.1.8	MATRIX SPIKE SAMPLE ANALYSIS	14

			<u>Page</u>
	3.1.9	FURNACE ATOMIC ABSORPTION OC	15
	3.1.10	SAMPLE RESULT VERIFICATION	15
	3.1.11	FIELD DUPLICATES/REPLICATES	15
3.2	SURFIC	CIAL SOIL INORGANICS (PHASE I, EP TOXICITY	
	METAI		16
	3.2.1	ANALYTICAL METHODS	
	3.2.2	SAMPLE HANDLING	
	3.2.3	HOLDING TIMES	
	3.2.4	CALIBRATION	
	3.2.5	BLANKS	
	3.2.6	LABORATORY CONTROL SAMPLES	
	3.2.7	DUPLICATE SAMPLE ANALYSIS	
	3.2.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.2.9	FURNACE ATOMIC ABSORPTION QC	
	3.2.10	SAMPLE RESULT VERIFICATION	
	3.2.11	FIELD DUPLICATES/REPLICATES	
	3.2.12	pH	_
3.3	SURFIC	CIAL SOIL INORGANICS (PHASE II; TOTAL METALS,	10
J.J	EP	······	19
	3.3.1	ANALYTICAL METHODS	
	3.3.2	SAMPLE HANDLING	
	3.3.3	HOLDING TIMES	
	3.3.4	CALIBRATION	
	3.3.5	BLANKS	
	3.3.6	LABORATORY CONTROL SAMPLES	
	3.3.7	DUPLICATE SAMPLE ANALYSIS	
	3.3.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.3.9	FURNACE ATOMIC ABSORPTION QC	
	3.3.10	SAMPLE RESULT VERIFICATION	
	3.3.10		
3.4		FIELD DUPLICATES/REPLICATES	
3.4	3.4.1	CIAL SOIL ORGANICS	
	3.4.1 3.4.2		
		HOLDING TIMES	23
	3.4.3	GC/MS TUNING	
	3.4.4	CALIBRATION	
	3.4.5	BLANKS	
	3.4.6	SURROGATE RECOVERY	
	3.4.7	MATRIX SPIKES AND MATRIX SPIKE DUPLICATE	
	3.4.8	FIELD DUPLICATES/REPLICATES	26
	3.4.9	INTERNAL STANDARDS PERFORMANCE	27
	3.4.10	TARGET COMPOUND IDENTIFICATION	27

			Page
	3.4.11	COMPOUND QUANTITATION AND DETECTION	
		LIMITS	27
	3.4.12	TENTATIVELY IDENTIFIED COMPOUNDS	28
3.5	SUBSUR	RFACE SOIL AND SLAG INORGANICS (PHASE I)	
	3.5.1	ANALYTICAL METHODS	
•	3.5.2	SAMPLE HANDLING	
	3.5.3	HOLDING TIMES	. 29
	3.5.4	CALIBRATION	
	3.5.5	BLANKS	
	3.5.6	LABORATORY CONTROL	
	3.5.7	DUPLICATE SAMPLES	
	3.5.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.5.9	INSTRUMENT QUALITY CONTROL	
	3.5.10	SAMPLE RESULT VERIFICATION	
	3.5.11	FIELD DUPLICATES/REPLICATES	
3.6		FACE SOIL AND SLAG INORGANICS (PHASE II)	
	3.6.1	ANALYTICAL METHODS	. 32
	3.6.2	SAMPLE HANDLING	
	3.6.3	HOLDING TIMES	
	3.6.4	CALIBRATION	
	3.6.5	BLANKS	-
	3.6.6	LABORATORY CONTROL SAMPLES	
	3.6.7	DUPLICATE SAMPLE ANALYSIS	. 33
	3.6.8	MATRIX SPIKE SAMPLE ANALYSIS	. 34
	3.6.9	FURNACE ATOMIC ABSORPTION	
	3.6.10	SAMPLE RESULT VERIFICATION	
	3.6.11	FIELD DUPLICATES/REPLICATES	
3.7		FACE SOIL AND SLAG ORGANICS DATA (PHASE I	35
J.,	3.7.1	ANALYTICAL METHODS	. 35
	3.7.2	HOLDING TIMES	
	3.7.3	GC/MS TUNING	
	3.7.4	CALIBRATION	
	3.7.5	BLANKS	
	3.7.6	SURROGATE RECOVERY	
	3.7.7	MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	36
	3.7.8		
	3.7.9	FIELD DUPLICATES/REPLICATES	. 36
	3.7.10	TARGET COMPOUND IDENTIFICATION	
	3.7.10	COMPOUND QUANTITATION AND DETECTION	. 50
	J. / . I I		. 36
	3.7.12	LIMITS TENTATIVELY IDENTIFIED COMPOUNDS	. 37
	J.1.14		. 51

			<u>Page</u>
3.8	SUBSUR	RFACE SOIL AND SLAG ORGANICS (PHASE II)	. 38
	3.8.1 A	NALYTICAL METHODS	. 38
	3.8.2	HOLDING TIMES	
	3.8.3	GC/MS TUNING	
	3.8.4	CALIBRATION	. 39
	3.8.5	BLANKS	
	3.8.6	SURROGATE RECOVERY	
	3.8.7	MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	39
	3.8.8	FIELD DUPLICATES/REPLICATES	
	3.8.9	INTERNAL STANDARDS PERFORMANCE	
	3.8.10	TARGET COMPOUND IDENTIFICATION	
	3.8.11	COMPOUND QUANTITATION AND DETECTION	
	J.0.11	LIMITS	. 40
	3.8.12	TENTATIVELY IDENTIFIED COMPOUNDS	
3.9	GROUN	DWATER INORGANICS (PHASE I)	. 41
	3.9.1	ANALYTICAL METHODS	: 41
	3.9.2	SAMPLE HANDLING	
	3.9.3	HOLDING TIMES	
	3.9.4	CALIBRATION	
	3.9.5	BLANKS	
	3.9.6	LABORATORY CONTROL	
	3.9.7	DUPLICATE SAMPLES	
	3.9.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.9.9	INSTRUMENT QUALITY CONTROL	
	3.9.10	SAMPLE RESULT VERIFICATION	
	3.9.11	FIELD DUPLICATES/REPLICATES	
3.10		DWATER INORGANICS (PHASE II)	
	3.10.1	ANALYTICAL METHODS	
	3.10.2	SAMPLE HANDLING	•
	3.10.3	HOLDING TIMES	•
	3.10.4	CALIBRATION	•
	3.10.5	BLANKS	-
	3.10.6	LABORATORY CONTROL SAMPLES	
	3.10.7	DUPLICATE SAMPLE ANALYSIS	. 45
	3.10.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.10.9	FURNACE ATOMIC ABSORPTION QC	
	3.10.10	SAMPLE RESULT VERIFICATION	
	3.10.10	FIELD DUPLICATES/REPLICATES	
3.11		DWATER ORGANICS (PHASE I)	. 47
J.11	3.11.1	ANALYTICAL METHODS	
	3.11.2	HOLDING TIMES	
	3.11.2	GC/MS TUNING	
	J.II.J	OC/MO IUMMO	. 7/

			<u>Page</u>
-	3.11.4	CALIBRATION	
	3.11.5	BLANKS	
	3.11.6	SURROGATE RECOVERY	
	3.11.7	MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	
	3.11.8	FIELD DUPLICATES/REPLICATES	. 48
	3.11.9	FIELD DUPLICATES/REPLICATES	. 48
	3.11.10	TARGET COMPOUND IDENTIFICATION	
	3.11.11	COMPOUND QUANTITATION AND DETECTION	
		LIMITS	. 49
	3.11.12	LIMITS TENTATIVELY IDENTIFIED COMPOUNDS	. 49
3.12	GROUN	IDWATER ORGANICS (PHASE II)	
	3.12.1	ANALYTICAL METHODS	
	3.12.2	HOLDING TIMES	
	3.12.3	GC/MS TUNING	
	3.12.4	CALIBRATION	
	3.12.5	BLANKS	
	3.12.6	SURROGATE RECOVERY	. 51
	3.12.7	MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	51
	3.12.8	FIELD DUPLICATES/REPLICATES	
	3.12.9	INTERNAL STANDARDS PERFORMANCE	. 52
	3.12.10	TARGET COMPOUND IDENTIFICATION	
	3.12.11	COMPOUND QUANTITATION AND DETECTION	
	0112011	LIMITS	
	3.12.12	TENTATIVELY IDENTIFIED COMPOUNDS	
3.13		EACHING INORGANICS	
0.10	3.13.1	ANALYTICAL METHODS	
	3.13.2	SAMPLING HANDLING	
	3.13.3	HOLDING TIMES	
	3.13.4	CALIBRATION	
	3.13.5	BLANKS	
	3.13.6	LABORATORY CONTROL SAMPLES	
	3.13.7	DUPLICATE SAMPLE ANALYSIS	
	3.13.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.13.9	FURNACE ATOMIC ABSORPTION QC	
	3.13.10	SAMPLE RESULT VERIFICATION	
	3.13.11	FIELD DUPLICATES/REPLICATES	
3.14		CE WATER INORGANICS	
J.1 <del>4</del>	3.14.1	ANALYTICAL METHODS	
	3.14.1 3.14.2	SAMPLE HANDLING	
	3.14.2 3.14.3	HOLDING TIMES	
	3.14.3 3.14.4		
		CALIBRATION	
	3.14.5	BLANKS	. 3/

			Page
	3.14.6	LABORATORY CONTROL SAMPLES	58
	3.14.7	DUPLICATE SAMPLE ANALYSIS	
	3.14.8	MATRIX SPIKE SAMPLE ANALYSIS	58
	3.14.9	FURNACE ATOMIC ABSORPTION QC	58
	3.14.10	SAMPLE RESULT VERIFICATION	
	3.14.11	FIELD DUPLICATES/REPLICATES	59
3.15	SURFA	CE WATER ORGANICS	
	3.15.1	ANALYTICAL METHODS	
	3.15.2	HOLDING TIMES	60
	3.15.3	GC/MS TUNING	61
	3.15.4	CALIBRATION	
	3.15.5	BLANKS	62
	3.15.6	SURROGATE RECOVERY	62
	3.15.7	MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	S 63
	3.15.8	FIELD DUPLICATES/REPLICATES	
	3.15.9	INTERNAL STANDARDS PERFORMANCE	63
	3.15.10	TARGET COMPOUND IDENTIFICATION	64
	3.15.11	COMPOUND QUANTITATION AND DETECTION	
			64
	3.15.12	LIMITS TENTATIVELY IDENTIFIED COMPOUNDS	64
3.16		CIAL MARINE SEDIMENT INORGANICS (PHASE I)	
	3.16.1	ANALYTICAL METHODS	
	3.16.2	SAMPLE HANDLING	
	3.16.3	HOLDING TIMES	
	3.16.4	CALIBRATION	
	3.16.5	BLANKS	
	3.16.6	LABORATORY CONTROL ANALYSIS	
	3.16.7	DUPLICATE SAMPLE ANALYSIS	
	3.16.8	MATRIX SPIKE SAMPLE ANALYSIS	
	3.16.9	FURNACE ATOMIC ABSORPTION QC	
	3.16.10	SAMPLE RESULT VERIFICATION	
	3.16.11	FIELD DUPLICATES/REPLICATES	
3.17		CIAL MARINE SEDIMENT INORGANICS (PHASE II, TOT	AI.
	METAL		
	3.17.1	ANALYTICAL METHODS	
	3.17.2	SAMPLE HANDLING	
	3.17.3	HOLDING TIMES	
	3.17.4	CALIBRATION	
	3.17.5	BLANKS	
	3.17.6	LABORATORY CONTROL SAMPLES	
	3.17.7	DUPLICATE SAMPLE ANALYSIS	
	3.17.8	MATRIX SPIKE SAMPLE ANALYSIS	

3.17.9   FURNACE ATOMIC ABSORPTION QC   70   3.17.10   SAMPLE RESULT VERIFICATION   70   3.17.11   FIELD DUPLICATES/REPLICATES   70   70   3.17.11   FIELD DUPLICATES/REPLICATES   70   70   3.17.11   FIELD DUPLICATES/REPLICATES   70   71   3.18.1   ANALYTICAL METHODS   71   3.18.2   SAMPLE HANDLING   71   3.18.2   SAMPLE HANDLING   71   3.18.3   HOLDING TIMES   71   3.18.4   CALIBRATION   71   3.18.5   BLANKS   72   3.18.6   LABORATORY CONTROL SAMPLES   72   3.18.7   DUPLICATE SAMPLE ANALYSIS   72   3.18.8   MATRIX SPIKE SAMPLE ANALYSIS   72   3.18.9   FURNACE ATOMIC ABSORPTION QC   72   3.18.10   SAMPLE RESULT VERIFICATION   72   3.18.11   FIELD DUPLICATES/REPLICATES   73   3.19.1   ANALYTICAL METHODS   74   3.19.1   ANALYTICAL METHODS   74   3.19.2   HOLDING TIMES   74   3.19.3   GC/MS TUNING   74   3.19.4   CALIBRATION   75   3.19.5   BLANKS   75   3.19.6   SURROGATE RECOVERY   76   3.19.6   SURROGATE RECOVERY   76   3.19.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   76   3.19.8   FIELD DUPLICATES/REPLICATES   78   3.19.9   INTERNAL STANDARDS PERFORMANCE   79   3.19.10   TARGET COMPOUND IDENTIFICATION   79   3.19.11   COMPOUND QUANTITATION AND DETECTION   LIMITS   80   3.20.1   ANALYTICAL METHODS   81   3.20.2   HOLDING TIMES   81   3.20.2   HOLDING TIMES   81   3.20.2   HOLDING TIMES   81   3.20.3   GC/MS TUNING   81   3.20.4   CALIBRATION   82   3.20.5   BLANKS   83   3.20.6   SURROGATE RECOVERY   83   3.20.6   SURROGATE RECOVERY   83   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   84   3.20.8   FIELD DUPLICATES/REPLICATES   83   3.20.6   SURROGATE RECOVERY   83   3.20.6   SURROGATE RECOVERY   83   3.20.6   SURROGATE RECOVERY   83   3.20.6   SURROGATE RECOVERY   83   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   84   3.20.1   TARGET COMPOUND DIENTIFICATION   86   3.20.10   TARGET COMPOUND DIENTIFICATION   86   3.20.10   TARGET COMPOUND DIENTIFICATION   86   3.20.10   TARGET COMPOUND DIENTIFICATION   86   3.20.10   TARGET COMPOUND DIENTIFICATION   86   3.20.10   TARGET COMPOUND DIENTIFICATI		-		<u>Page</u>
TOXICITY METALS    71   3.18.1   ANALYTICAL METHODS   71   3.18.2   SAMPLE HANDLING   71   3.18.2   SAMPLE HANDLING   71   3.18.3   HOLDING TIMES   71   3.18.4   CALIBRATION   71   3.18.5   BLANKS   72   3.18.6   LABORATORY CONTROL SAMPLES   72   3.18.7   DUPLICATE SAMPLE ANALYSIS   72   3.18.8   MATRIX SPIKE SAMPLE ANALYSIS   72   3.18.9   FURNACE ATOMIC ABSORPTION QC   72   3.18.10   SAMPLE RESULT VERIFICATION   72   3.18.11   FIELD DUPLICATES/REPLICATES   73   3.19.1   ANALYTICAL METHODS   74   3.19.2   HOLDING TIMES   74   3.19.3   GC/MS TUNING   74   3.19.4   CALIBRATION   75   3.19.5   BLANKS   75   3.19.6   SURROGATE RECOVERY   76   3.19.8   FIELD DUPLICATES/REPLICATES   78   3.19.8   FIELD DUPLICATES/REPLICATES   78   3.19.6   SURROGATE RECOVERY   76   3.19.6   SURROGATE RECOVERY   76   3.19.6   SURROGATE RECOVERY   76   3.19.8   FIELD DUPLICATES/REPLICATES   78   3.19.10   TARGET COMPOUND IDENTIFICATION   79   3.19.10   TARGET COMPOUND IDENTIFICATION   79   3.19.11   COMPOUND QUANTITATION AND DETECTION   LIMITS   80   3.20.1   ANALYTICAL METHODS   81   3.20.2   HOLDING TIMES   81   3.20.3   GC/MS TUNING   81   3.20.4   CALIBRATION   82   3.20.5   BLANKS   83   3.20.6   SURROGATE RECOVERY   83   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   81   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   81   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   83   3.20.6   SURROGATE RECOVERY   83   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   84   3.20.8   FIELD DUPLICATES/REPLICATES   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85   3.20.9   INTERNAL STANDARDS PERFORMANCE	2 10	3.17.10 3.17.11	SAMPLE RESULT VERIFICATION FIELD DUPLICATES/REPLICATES	. 70 . 70
3.18.1 ANALYTICAL METHODS	3.10			
3.18.2       SAMPLE HANDLING       71         3.18.3       HOLDING TIMES       71         3.18.4       CALIBRATION       71         3.18.5       BLANKS       72         3.18.6       LABORATORY CONTROL SAMPLES       72         3.18.7       DUPLICATE SAMPLE ANALYSIS       72         3.18.8       MATRIX SPIKE SAMPLE ANALYSIS       72         3.18.9       FURNACE ATOMIC ABSORPTION QC       72         3.18.10       SAMPLE RESULT VERIFICATION       72         3.18.11       FIELD DUPLICATES/REPLICATES       73         3.19.1       ANALYTICAL METHODS       74         3.19.2       HOLDING TIMES       74         3.19.2       HOLDING TIMES       74         3.19.3       GC/MS TUNING       74         3.19.4       CALIBRATION       75         3.19.5       BLANKS       75         3.19.6       SURNGGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION       10         LIMITS<			ANAI VTICAI METHODS	71
3.18.3       HOLDING TIMES       71         3.18.4       CALIBRATION       71         3.18.5       BLANKS       72         3.18.6       LABORATORY CONTROL SAMPLES       72         3.18.7       DUPLICATE SAMPLE ANALYSIS       72         3.18.8       MATRIX SPIKE SAMPLE ANALYSIS       72         3.18.9       FURNACE ATOMIC ABSORPTION QC       72         3.18.10       SAMPLE RESULT VERIFICATION       72         3.18.11       FIELD DUPLICATES/REPLICATES       73         3.19.1       ANALYTICAL METHODS       74         3.19.2       HOLDING TIMES       74         3.19.3       GC/MS TUNING       74         3.19.4       CALIBRATION       75         3.19.5       BLANKS       75         3.19.6       SURROGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20.1       ANALYTICAL METHODS       81				
3.18.4   CALIBRATION				
3.18.5 BLANKS   72				
3.18.6 LABORATORY CONTROL SAMPLES 72 3.18.7 DUPLICATE SAMPLE ANALYSIS 72 3.18.8 MATRIX SPIKE SAMPLE ANALYSIS 72 3.18.9 FURNACE ATOMIC ABSORPTION QC 72 3.18.10 SAMPLE RESULT VERIFICATION 72 3.18.11 FIELD DUPLICATES/REPLICATES 73 3.19 SURFICIAL MARINE SEDIMENT ORGANICS (PHASE I) 74 3.19.1 ANALYTICAL METHODS 74 3.19.2 HOLDING TIMES 74 3.19.3 GC/MS TUNING 74 3.19.4 CALIBRATION 75 3.19.5 BLANKS 75 3.19.6 SURROGATE RECOVERY 76 3.19.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 76 3.19.8 FIELD DUPLICATES/REPLICATES 78 3.19.9 INTERNAL STANDARDS PERFORMANCE 79 3.19.10 TARGET COMPOUND IDENTIFICATION 79 3.19.11 COMPOUND QUANTITATION AND DETECTION LIMITS 80 3.20.1 ANALYTICAL METHODS 80 3.20.2 HOLDING TIMES 81 3.20.3 GC/MS TUNING 81 3.20.4 CALIBRATION 82 3.20.5 BLANKS 83 3.20.6 SURROGATE RECOVERY 83 3.20.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 84 3.20.8 FIELD DUPLICATES/REPLICATES 83 3.20.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 84 3.20.8 FIELD DUPLICATES/REPLICATES 84 3.20.9 INTERNAL STANDARDS PERFORMANCE 85				
3.18.7   DUPLICATE SAMPLE ANALYSIS   72     3.18.8   MATRIX SPIKE SAMPLE ANALYSIS   72     3.18.9   FURNACE ATOMIC ABSORPTION QC   72     3.18.10   SAMPLE RESULT VERIFICATION   72     3.18.11   FIELD DUPLICATES/REPLICATES   73     3.19   SURFICIAL MARINE SEDIMENT ORGANICS (PHASE I)   74     3.19.1   ANALYTICAL METHODS   74     3.19.2   HOLDING TIMES   74     3.19.3   GC/MS TUNING   74     3.19.4   CALIBRATION   75     3.19.5   BLANKS   75     3.19.6   SURROGATE RECOVERY   76     3.19.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   76     3.19.8   FIELD DUPLICATES/REPLICATES   78     3.19.9   INTERNAL STANDARDS PERFORMANCE   79     3.19.10   TARGET COMPOUND IDENTIFICATION   79     3.19.11   COMPOUND QUANTITATION AND DETECTION     LIMITS   80     3.20   SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)   81     3.20.1   ANALYTICAL METHODS   81     3.20.2   HOLDING TIMES   81     3.20.3   GC/MS TUNING   81     3.20.4   CALIBRATION   82     3.20.5   BLANKS   83     3.20.6   SURROGATE RECOVERY   83     3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   84     3.20.8   FIELD DUPLICATES/REPLICATES   85     3.20.9   INTERNAL STANDARDS PERFORMANCE   85				
3.18.8 MATRIX SPIKE SAMPLE ANALYSIS 3.18.9 FURNACE ATOMIC ABSORPTION QC 3.18.10 SAMPLE RESULT VERIFICATION 3.18.11 FIELD DUPLICATES/REPLICATES 3.19 SURFICIAL MARINE SEDIMENT ORGANICS (PHASE I) 3.19.1 ANALYTICAL METHODS 3.19.2 HOLDING TIMES 3.19.3 GC/MS TUNING 3.19.4 CALIBRATION 3.19.5 BLANKS 3.19.6 SURROGATE RECOVERY 3.19.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 3.19.8 FIELD DUPLICATES/REPLICATES 3.19.9 INTERNAL STANDARDS PERFORMANCE 3.19.10 TARGET COMPOUND IDENTIFICATION 2.19.11 COMPOUND QUANTITATION AND DETECTION 2.19.12 TENTATIVELY IDENTIFIED COMPOUNDS 3.20 SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II) 3.20.1 ANALYTICAL METHODS 3.20.2 HOLDING TIMES 3.20.3 GC/MS TUNING 3.20.4 CALIBRATION 3.20.5 BLANKS 3.20.6 SURROGATE RECOVERY 3.20.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 3.20.8 FIELD DUPLICATES/REPLICATES 3.20.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 3.20.8 FIELD DUPLICATES/REPLICATES 3.20.8 FIELD DUPLICATES/REPLICATES 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.9 INTERNAL STANDARDS PERFORMANCE 3.20.5 INTERNAL STANDARDS PERFORMANCE 3.20.5 INTERNAL STANDARDS PERFORMANCE 3.20.5 INTERNAL STANDARDS PERFORMANCE 3.20.5 INTERNAL STANDARDS PERFORMANCE 3.20.5 INTERNAL STANDARDS PERFORMANCE 3.20.6 INTERNAL STANDARDS PERFORMANCE				
3.18.9   FURNACE ATOMIC ABSORPTION QC   72   3.18.10   SAMPLE RESULT VERIFICATION   72   3.18.11   FIELD DUPLICATES/REPLICATES   73   73   3.19   SURFICIAL MARINE SEDIMENT ORGANICS (PHASE I)   74   3.19.1   ANALYTICAL METHODS   74   3.19.2   HOLDING TIMES   74   3.19.3   GC/MS TUNING   74   3.19.4   CALIBRATION   75   3.19.5   BLANKS   75   3.19.6   SURROGATE RECOVERY   76   3.19.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   76   3.19.8   FIELD DUPLICATES/REPLICATES   78   3.19.9   INTERNAL STANDARDS PERFORMANCE   79   3.19.10   TARGET COMPOUND IDENTIFICATION   79   3.19.11   COMPOUND QUANTITATION AND DETECTION   LIMITS   80   3.19.12   TENTATIVELY IDENTIFIED COMPOUNDS   80   3.20.1   ANALYTICAL METHODS   81   3.20.2   HOLDING TIMES   81   3.20.3   GC/MS TUNING   81   3.20.4   CALIBRATION   82   3.20.5   BLANKS   83   3.20.5   BLANKS   83   3.20.6   SURROGATE RECOVERY   83   3.20.7   MATRIX SPIKES AND MATRIX SPIKE DUPLICATES   84   3.20.8   FIELD DUPLICATES/REPLICATES   85   3.20.9   INTERNAL STANDARDS PERFORMANCE   85				
3.18.10 SAMPLE RESULT VERIFICATION				
3.18.11 FIELD DUPLICATES/REPLICATES				
3.19       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE I)       74         3.19.1       ANALYTICAL METHODS       74         3.19.2       HOLDING TIMES       74         3.19.3       GC/MS TUNING       74         3.19.4       CALIBRATION       75         3.19.5       BLANKS       75         3.19.6       SURROGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION       LIMITS         MATRIX SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85				
3.19.1 ANALYTICAL METHODS	3 10			
3.19.2       HOLDING TIMES       74         3.19.3       GC/MS TUNING       74         3.19.4       CALIBRATION       75         3.19.5       BLANKS       75         3.19.6       SURROGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION LIMITS       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20.1       ANALYTICAL METHODS       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85	3.17			
3.19.3 GC/MS TUNING				
3.19.4       CALIBRATION       75         3.19.5       BLANKS       75         3.19.6       SURROGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20.1       ANALYTICAL METHODS       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				
3.19.5       BLANKS       75         3.19.6       SURROGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION LIMITS       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				
3.19.6       SURROGATE RECOVERY       76         3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION LIMITS       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20.1       ANALYTICAL METHODS       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				-
3.19.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       76         3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20.1       ANALYTICAL METHODS       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				
3.19.8       FIELD DUPLICATES/REPLICATES       78         3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85			MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	76
3.19.9       INTERNAL STANDARDS PERFORMANCE       79         3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION LIMITS       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				
3.19.10       TARGET COMPOUND IDENTIFICATION       79         3.19.11       COMPOUND QUANTITATION AND DETECTION       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85			INTERNAL STANDARDS PERFORMANCE	
3.19.11       COMPOUND QUANTITATION AND DETECTION LIMITS       80         3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				
LIMITS				• .,
3.19.12       TENTATIVELY IDENTIFIED COMPOUNDS       80         3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85		0.127.11		. 80
3.20       SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)       81         3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85		3.19.12		
3.20.1       ANALYTICAL METHODS       81         3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85	3.20			
3.20.2       HOLDING TIMES       81         3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85	• • • • • • • • • • • • • • • • • • • •			
3.20.3       GC/MS TUNING       81         3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85	-			
3.20.4       CALIBRATION       82         3.20.5       BLANKS       83         3.20.6       SURROGATE RECOVERY       83         3.20.7       MATRIX SPIKES AND MATRIX SPIKE DUPLICATES       84         3.20.8       FIELD DUPLICATES/REPLICATES       85         3.20.9       INTERNAL STANDARDS PERFORMANCE       85				
3.20.5 BLANKS			CALIBRATION	. 82
3.20.6 SURROGATE RECOVERY		<del>-</del> -		
3.20.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES 84 3.20.8 FIELD DUPLICATES/REPLICATES 85 3.20.9 INTERNAL STANDARDS PERFORMANCE 85			SURROGATE RECOVERY	83
3.20.8 FIELD DUPLICATES/REPLICATES			MATRIX SPIKES AND MATRIX SPIKE DUPLICATES	84
3.20.9 INTERNAL STANDARDS PERFORMANCE 85			FIELD DUPLICATES/REPLICATES	. 85
			INTERNAL STANDARDS PERFORMANCE	. 85

				-					-	<u>F</u>	age
		3.20.11	COMPOUND QUANTITATION AN	۷D	DI	ETE	ECTI	ON	ī		
			LIMITS								86
	3.21	MARINE	SEDIMENT CORE INORGANICS								87
		3.21.1	ANALYTICAL METHODS								87
		3.21.2	SAMPLE HANDLING								87
		3.21.3	HOLDING TIMES								87
		3.21.4	CALIBRATION								87
		3.21.5	BLANKS								88
		3.21.6	LABORATORY CONTROL SAMPI	LE:	S.						88
		3.21.7	<b>DUPLICATE SAMPLE ANALYSIS</b>								88
		3.21.8	MATRIX SPIKE SAMPLE ANALYS	SIS							88
		3.21.9	FURNACE ATOMIC ABSORPTION	N (	QC						89
		3.21.10	SAMPLE RESULT VERIFICATION								89
		3.21.11	FIELD DUPLICATES/REPLICATE	ES							89
	3.22	MARINE									90
		3.22.1	ANALYTICAL METHODS								90
		3.22.2	HOLDING TIMES								90
		3.22.3	GC/MS TUNING								90
		3.22.4	CALIBRATION								90
		3.22.5	BLANKS								91
		3.22.6	SURROGATE RECOVERY								91
		3.22.7	MATRIX SPIKES AND MATRIX S	SPI	ΚE	D	JPLI	CA	TES	5.	92
		3.22.8	FIELD DUPLICATES/REPLICATE	S						•-	92
		3.22.9	INTERNAL STANDARDS PERFOR	RM	[AN	<b>ICE</b>	E				93
		3.22.10	TARGET COMPOUND IDENTIFIC								93
		3.22.11	COMPOUND QUANTITATION AN	ND	DI	ETE	ECTI	ON	Ī		
			LIMITS		٠.						93
4.	CON	CLUSIONS	, , , , , , , , , , , , , , , , , , , ,							_	94
				•	••	•	•	•	• • •	•	
5.											95
	5.1	QA MEN	IORANDA								95

#### 1. INTRODUCTION

This Laboratory Data Validation report (Volume III of the ASARCO Tacoma Smelter Remedial Investigation) presents our validation of the Sample Data Package for chemical analyses of samples collected for Phase I and Phase II of the Remedial Investigation. Inorganic and organic chemical analyses were performed on surficial soil, subsurface soil or slag, groundwater, fill leachate, surface water, surficial marine sediments, and marine sediment core samples collected on or near the ASARCO Tacoma Smelter site. Our review of the Sample Data Package was performed in accordance with Laboratory Data Validation Function Guidelines (USEPA 1987, USEPA 1988) in fulfillment of a requirement by EPA issued to ASARCO in April 1988.

Samples were collected and handled in accordance with the Sampling and Analysis Plans for the ASARCO Tacoma Smelter Remedial Investigation (Parametrix et al. 1987) and the Program Quality Assurance Plan for the ASARCO Tacoma Smelter Remedial Investigation (Parametrix 1986) approved by the U.S. Environmental Protection Agency. Phase I samples were collected during the months of August through November 1987. Phase II sampling began in June 1988 and was completed in January 1989. Fill leachate and marine sediment core sampling were conducted during Phase II only, and surface water samples were collected in the months of January, April, and June 1988. The samples were shipped to the ASARCO Salt Lake City (SLC), Utah laboratory for analyses of inorganic parameters. Additional samples were shipped by ASARCO SLC to Lancaster Laboratories, Inc., for analyses of organic compounds and to Controls for Environmental Pollution, Inc., for analyses of radiological parameters (Phase I only). The methods used for chemical analyses are listed in Table 1-1.

Table 1-1. Summary of chemical analyses methods.

Parameter	Reference/Method
Total Metals (Soil)	
Antimony	CLP SOW 1986/EPA 204.1
Arsenic	CLP SOW 1986/EPA 206.2, .3, .4
Barium	CLP SOW 1986/EPA 208.1
Cadmium	CLP SOW 1986/EPA 213.1
Chromium	CLP SOW 1986/EPA 218.1
Copper	CLP SOW 1986/EPA 220.1
Lead	CLP SOW 1986/EPA 239.1, .2
Mercury	CLP SOW 1986/EPA 245.1
Nickel	CLP SOW 1986/EPA 249.1
Selenium	CLP SOW 1986/EPA 270.1, .2, .3
Silver	CLP SOW 1986/EPA 272.1
Thallium	CLP SOW 1986/EPA 279.1
Zinc	CLP SOW 1986/EPA 289.1
Extractable (EP Tox) Metals (Soil)  Same parameters and methods as Total Metals ex	reent extraction procedures followed SW
1310.	ecept extraction procedures followed 5 w
Organic Parameters (Soil)	
Semivolatile Organics	SW 3550/SW 8270
Pesticides and PCBs	SW 3550/SW 8080
Benzene, Toluene, Ethylbenzene, and	<b>3</b>
Xylenes (BTEX)	SW 5030/SW 8020
Total Petroleum Hydrocarbons (TPH)	SW 3540/EPA 418.1
GC-FID Screen	GC-FID
CW	MCC as March and Con Translation Collid
SW	"Test Methods for Evaluating Solid
	Waste (SW 846), U.S.E.P.A.,"
	November 1986.
EPA	"Methods for Chemical Analysis of
	Water and Wastes, U.S.E.P.A.,"
	March 1983.
CLP SOW	"ASARCO Laboratory - EPA
•	Contract Lab Program Statement
	of Work," 1986.

Table 1-1. Summary of chemical analyses methods (continued).

Table 1-1. Summary of chemical analyse	es methods (continued).
Parameter	Reference/Method
Total Metals (Water)	
Antimony Arsenic Barium Cadmium Chromium Copper Lead Mercury	LAP 6/24/86/EPA 204.1 LAP 6/24/86/EPA 206.2, .3, .4 LAP 6/24/86/EPA 208.1 LAP 6/24/86/EPA 213.1 LAP 6/24/86/EPA 218.1 LAP 6/24/86/EPA 220.1 LAP 6/24/86/EPA 239.1, .2 LAP 6/24/86/EPA 245.1
Nickel Selenium Silver Thallium Zinc	LAP 6/24/86/EPA 249.1 LAP 6/24/86/EPA 270.1, .2, .3 LAP 6/24/86/EPA 272.1 LAP 6/24/86/EPA 279.1 LAP 6/24/86/EPA 289.1
preservation.	e filtered with a 0.45 micron filter before
Miscellaneous Inorganics (Water)  Sodium Iron Potassium Magnesium Manganese Calcium Chloride Sulfate Bicarbonate Alkalinity Sulfide	EPA 273.1 EPA 236.1 SM 303 H EPA 242.1 EPA 243.1 EPA 215.1 EPA 300.0 EPA 375.2 EPA 310.1 EPA 376.1 or EPA 376.2

## Organic Parameters (Water)

Total Organic Carbon (TOC)

Benzene, Toluene, Ethylbenzene and Xylenes
Total Petroleum Hydrocarbons (TPH)

Purge and Trap/SW 8020
EPA 418.1

SW 3520/EPA 415.1

Table 1-1. Summary of chemical analyses methods (continued).

Parameter	Reference/Method
SM	"Standard Methods for the Examination of Water and Wastewater", 15th edition, 1980, American Public Health Association.
ŚW	"Test Methods for Evaluating Solid Waste (SW 846), U.S.E.P.A.," November 1986.
EPA	"Methods for Chemical Analysis of Water and Wastes, U.S.E.P.A.," March 1983.
LAP ASARCO Laboratory in-h	souse method or modification of a previously published

#### 2. SUMMARY OF FINDINGS

Based on our data validation review, we judged the analytical data to be generally acceptable as valid for the purposes of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Only a few data were rejected as unusable. In some cases, results were qualified as estimates due to violations of quality control criteria. Data qualifier codes are defined in Table 2-1.

Table 2-1. Definitions for data qualifier codes - ASARCO RI/FS

<	Less than. The associated value was the quantitation (detection) limit.
J	Indicates an estimated value because one or more quality control criteria were not met.
N	The associated quantitation limit is estimated because one or more quality control criteria were not met.
R	Quality control indicates that the datum is unusable and the compound may or may not be present. Resampling and reanalysis would be necessary for verification.
U	The compound was judged to be undetected due to blank contamination. The associated value is the estimated sample quantitation limit.
Z	Results were not reported by the laboratory on a dry-weight basis.
W	This qualifier is restricted to the furnace atomic absorption spectraphotometry (Furnace AA) analysis of lead. "W" indicates the sample absorbance was less than 50 percent of the spike absorbance and the spike recovery was less than 85 percent or greater than 115 percent.
E	Indicates the spike recovery was less than 40 percent in the furnace AA analysis of lead.
•	This sample was lost by the laboratory.
#	The laboratory did not report this total organic carbon (TOC) result because the non-homogeneous nature of the sample made it difficult to get reproducible results.

Detailed discussions of the laboratory data validation are contained in Chapter 4 and the appendices of this volume. The following sections of Chapter 2 summarize the flagging of data with qualifier codes.

#### 2.1 SURFICIAL SOIL

Analytical results for surficial soil samples are generally valid for the purposes of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Phase I analyses included total metals, EP Toxicity metal, semi-volatile organics and PCBs. Phase II surficial soils were analyzed for total metals and EP Toxicity metals.

#### 2.1.1 INORGANICS (PHASE I, TOTAL METALS)

All mercury results were flagged as estimates (J or N) due to holding time violations. Also, one of the standard curves used for mercury quantitation had a low correlation coefficient.

All cadmium and lead results were flagged as estimates (J or N) due to low correlation coefficients for standard curves.

Antimony results for samples SS-28, SS-40, SS-47, SS-48, SS-36, SS-6, and SS-3 were flagged as estimates (J) because continuing calibration verification recoveries indicated sample results may have been biased high.

#### 2.1.2 INORGANICS (PHASE I, EP TOXICITY METALS)

All mercury results were flagged as estimates (J or N) due to holding time violations.

All cadmium results were flagged as estimates (J or N) due to low correlation coefficients for standard curves.

#### 2.1.3 INORGANICS (PHASE II)

All mercury results were flagged as estimates (J or N) due to holding time violations.

ICV recoveries for selenium indicated EP Tox results for samples SS2-01 and SS2-22 may be biased high, thus selenium results for these samples were flagged as estimated (J). A low CCV recovery for selenium indicated that results for SS2-02 and SS2-15 may be biased low, thus selenium results for thee samples were flagged as detection limit estimates (N).

Matrix spike recoveries indicated total antimony results may be biased low, thus all total antimony data were flagged as estimates (J or N). A high matrix spike recovery for arsenic indicated depth study sample results may be biased high, thus positive arsenic data for these samples were flagged as estimates (J).

#### 2.1.4 ORGANICS

All PCB results were flagged as estimates (J or N) due to holding time violations and unacceptable linearity of calibration standards.

Semi-volatile organics results for samples documented in Memorandum 59 (Appendix Q) were flagged as estimates (J or N) due to holding time violations.

All semi-volatile organics results less than detection limits were flagged as unusable (R) for sample SS-70 due to poor surrogate recovery.

All positive semi-volatile organics results were flagged as estimates (J) and all negative semi-volatile results were flagged as unusable (R) for sample SS-MW-5-S-1 because surrogate recovery of phenol was less than 10 percent. Semi-volatile results for sample SS-21 were similarly qualified because the surrogate recovery of nitrobenzene-d5 was less than 10 percent.

Positive results for pyrene were flagged as estimates (J) in samples documented in Memorandum S6 (Appendix Q) and negative pyrene results were flagged as unusable (R) in these samples. Matrix spike recoveries of pyrene associated with Memorandum S6 samples were unacceptable. Positive results for pyrene in Memorandum S3 (Appendix Q) samples were also flagged as estimates (J) due to unacceptable matrix spike recovery.

Sample matrix interferences resulted in internal standard areas that did not meet quality control criteria. When diluted samples were re-injected and re-analyzed and the standard areas were still outside limits, compounds associated with these standards were flagged as estimates (J or N). Other samples associated with unacceptable internal standard results were not re-analyzed and these samples were similarly qualified.

#### 2.2 SUBSURFACE SOIL OR SLAG

We have determined that the laboratory data generated from Phase I and II analysis of soil samples are generally valid for the purposes of this ASARCO Tacoma Smelter Remedial Investigation and Feasibility study. A summary of Phase I and II soil results are presented in Volume II. Some of the data required qualification. Data qualifications are described in the following sections.

#### 2.2.1 INORGANICS (PHASE I)

Mercury analysis of samples MW-4, S-2, and MW-6, S-3 were qualified as estimates.

#### 2.2.2 INORGANICS (PHASE II)

Selenium spike recoveries were consistently below 75 percent. Sample results above the detection limit were flagged as estimated (J). Sample results below the detection limit were flagged as unusable (R).

Correlation coefficients for nickel, selenium, and zinc analyses were less than 0.995. Sample results associated with these calibration curves were flagged as estimates (J).

#### 2.2.3 ORGANICS (PHASE I)

No data qualification was necessary.

#### 2.2.4 ORGANICS (PHASE II)

Thirteen samples collected during Phase 1 were submitted for semivolatile organic analysis as part of Phase 2. Holding times for these samples was approximately one year. Results were flagged as estimated (J).

Di-n-butylphthalate and bis(2-ethylhexyl) phthalate had percent differences (percent D) between initial and continuing relative response factors greater than 25 percent in at least one of the continuing calibration standards. Results for these two compounds were flagged as estimated (J) when the percent D criteria was exceeded.

TPH concentrations in laboratory blanks ranged from 30 to 33 mg/kg total petroleum hydrocarbons. Sample results below 5 times the detected TPH blank concentration were qualified as not detected (U).

#### 2.3 GROUNDWATER

We have determined that the laboratory data generated from Phase I and II analysis of groundwater samples are valid for the purposes of the ASARCO Tacoma Remedial Investigation and Feasibility study. A summary of Phase I and II groundwater results are presented in Volume III. Some of the data required qualification. Data qualifiers are described in the following sections.

#### 2.3.1 INORGANICS (PHASE I)

Mercury analysis of sample MW-3A2 and arsenic analysis of sample MW-13 were qualified as estimates.

#### 2.3.2 INORGANICS (PHASE II)

Calibration correlation coefficients were below 0.995 for lead and nickel. Corresponding samples were flagged as estimated (J).

MW-1B (low tide) and MW-1B (high tide) selenium results were qualified as estimated (J) because they were below 5 times the selenium blank concentration.

Total and dissolved lead in sample MW-2A were qualified as estimated (J) due to spike recoveries below 40 percent. Dissolved lead in samples MW-2A (medium tide) and MW-3A2 (low tide) were also flagged as estimated due to low spike recoveries. Samples with absorbances less than 50 percent of the spike absorbance and spike recoveries that fell outside the 85 to 115 percent range were flagged as estimates (J).

#### 2.3.3 ORGANICS (PHASE I)

Data for the undetected compound, 3-nitroaniline is unusable due to low average relative response factors.

#### 2.3.4 ORGANICS (PHASE II)

Volatile aromatic compounds exceeded the 7 day holding time requirement. Volatile aromatic compound results were flagged as estimated (J) excluding sample B-16.

Total Petroleum Hydrocarbon (TPH) results in samples B-33 and B-34 were qualified as not detected (U) because they were below 5 times the detected TPH blank concentration.

#### 2.4 FILL LEACHING INORGANICS

We have determined that the laboratory data generated from the analysis of soil and water sampled during the leachate testing study are valid for the purposes of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Leachate testing results are summarized in Appendix L. Some of the data required qualification. Data qualifiers are described below.

The required holding time for mercury (28 days) was exceeded for all samples. Mercury results in water samples were flagged as estimates (J).

Correlation coefficients for nickel (2 to 10 ppm) and zinc (20 to 100 ppm) analyses were less than 0.995. Water sample results associated with these calibration curves were flagged as estimates (J).

Total and dissolved lead sample results with absorbances less than 50 percent of the spike absorbance and spike recoveries that fell outside the 85 to 115 percent range were flagged as estimates (J).

#### 2.5 SURFACE WATER

Analytical results for surface water samples are valid for the purpose of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Surface water analyses included total suspended solids (TSS), total metals, dissolved metals, semi-volatile organics, and PCBs. Three rounds of samples were collected during separate storm events.

#### 2.5.1 INORGANICS

Mercury results for the two tunnel seep samples (Seep-A and Seep-B) were flagged as estimates (J or N) because the holding time requirement was exceeded.

The dissolved lead result for sample SW-1, Round 1 was flagged as an estimate (J) because the associated continuing calibration verification (CCV) recovery exceeded control limits. The Round 3 initial calibration verification (ICV) recovery for antimony was less than the minimum allowed by quality control limits, thus all Round 3 antimony results were flagged as estimates (J or N).

Round 1 lead results for samples SW-1, SP-5, and SW-11 were flagged as estimates (J) because no blanks were tested with the graphite furnace analysis. Similarly, no blanks were tested with the flame AA analysis of arsenic for Round 2, thus arsenic results for the following Round 2 samples were flagged as estimates (J): 2056T, 2058T, 2059D, 2059T, 2068T, 2076T, and 2079T.

Round 2 dissolved copper and dissolved zinc results were flagged as estimates (J) where sample concentrations were less than five times the rinsate blank concentrations. Dissolved zinc and total zinc were detected in the Round 3 rinsate blank, thus Round 3 zinc results were flagged as estimates (J) where sample concentrations were less than five times the blank concentrations.

The laboratory flagged the furnace AA dissolved lead result for sample SW-1 from Round 1 with a "W" according to Contract Laboratory Program (CLP) protocol. The laboratory also flagged Round 3 dissolved lead results for samples SW-6 and SEEP 5 with a "W"; and flagged the total lead and dissolved lead results for SW-11G in Round 2 with an "E." The "W" and "E" qualifiers were changed to "J" to comply with Data Validation Guidelines.

#### 2.5.2 ORGANICS

Two samples had internal standard areas below the lower limit for perylene (SP-5 and SEC B) so compounds associated with perylene are flagged as estimates (J or N).

#### 2.6 SURFICIAL MARINE SEDIMENT

Analytical results for surficial marine sediment samples are generally valid for the purposes of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Phase I surficial marine sediments were analyzed for total metals and semi-volatile organic compounds. Phase II analyses included total metals, EP Tox metals, semi-volatile organics, and PCBs.

#### 2.6.1 INORGANICS (PHASE I)

All flameless AA arsenic results were flagged as estimates (J) due to low correlation coefficients of calibration standards and low recoveries of ICV and CCV samples. Flame AA arsenic results were flagged as estimates (J) due to the lack of information regarding possible sample contamination and the effects of the sample matrix on the digestion and measurement methodology.

#### 2.6.2 ORGANICS (PHASE II, TOTAL METALS)

Mercury results for those samples with holding times greater than 28 days were flagged as estimates (J or N). Mercury results for samples T4-4, T3-6, T3-5, T3-4, T2-5, T2A-5, T2-60, and T4-1 combined were flagged as estimates (J) due to low matrix spike recovery.

#### 2.6.3 INORGANICS (PHASE II, TOXICITY METALS)

Mercury results for those samples with holding times greater than 28 days were flagged as estimates (J or N).

#### 2.6.4 ORGANICS (PHASE I)

All analyses of semi-volatile organics were within the control limit of 7 days except for MSO-3-3 which was re-extracted 20 days after sample collection. Therefore, all data for MSO-3-3 were flagged as estimates (J or N).

Blank Contamination: Analysis of blanks associated with the following samples showed contamination that required data qualification action.

- MSO-7-7: showed levels of diethylphthalate that were greater than in the blank but less than 5 times the blank concentration. Qualified as undetected (N).
- MSO-14-3, MSO-14-2, MSO-15-2, MSO-15-3, MSO-12-2, and MSO-12-3 showed approximately the same levels of Di-n-butylphthalate and Bis-2-ethylhexylphthalate as the blank. Data for these compounds is qualified as unusable (R).

Spike Recoveries: In general, the matrix spike/matrix spike duplicate results showed acceptable precision and accuracy of the methodology and procedures. The recovery of pyrene in the matrix spike and matrix spike duplicate samples associated with MSO-8-2 was -347% and -18% respectively (i.e., essentially zero). Even though MS/MSD results are not typically used to quantify individual samples, in this case the trace amounts of pyrene (below the specified detection limits) found in the sample are qualified as detection limit estimates (N).

Internal Standard Areas: The following standard area compounds did not meet QA limits, requiring estimate qualifications (J or N) to the data for associated compounds in the samples listed.

- Chrysene-d12: MSO-10-2.
- Naphthalene-d4: MSO-3-1, MSO-4-0, MSO-9-3, and MSO-10-2.
- Acenaphthene-d10: MSO-3-1.
- Phenanthrene-d10: MSO-2-3, MSO-3-2, and MSO-4-0.

• 1,4-Dichlorobenzene-d5: MSO-4-0, MSO-7-7, MSO-9-3, and MSO-10-2.

#### 2.6.5 ORGANICS (PHASE II)

All analyses of semi-volatile organics were within the control limit of 7 days except for the following samples, for which all data were flagged as estimates (J or N).

- T22-1, T22-2, and T4-4 were re-extracted 22 days after sample collection.
- T3-5, T3-4, T2-5, and T3-6 re-extracted 25 days after sample collection.
- T2A-5, T2A-50, and T2-6 were warm when they were received at ASARCO Technical Service Center. This violated the protocol for holding the samples.

The spike recovery of arochlor 1242 was below the control limits for the following samples T3-2, T4-2, T4-20, T8-4, T6-3, and T6-1. As a result the PCB data will be flagged as estimates in these samples.

#### 2.7 MARINE SEDIMENT CORES

Analytical results for marine sediment core samples are valid for the purposes of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Core samples were analyzed for total metals, EP Tox metals, and semi-volatile organic compounds.

#### 2.7.1 INORGANICS

All mercury results were flagged as estimates (J or N) because the holding time limit was exceeded.

EP Tox arsenic results for samples 10A-01, T7-2-01, T7-2-12, T7-2-23, T7-2-34, T7-2-45, T13-2.5-01, T13-2.5-12, T13-2.5-23, and T13-2.5-34 were flagged as estimates (J) because the ICV recovery exceeded control limits.

#### 2.7.2 ORGANICS

The holding times to extraction for semi-volatile organics analysis exceeded the control limit of seven days for all coring samples. Therefore, all the positive results are flagged as estimates (J) and all negative results as non-detected at the estimated detection limits (N).

The surrogate recoveries were generally within control limits established in the CLP with the following exceptions:

• 2-fluorobiphenyl and nitrobenzene were below recovery limits in sample 10A-12. Since two surrogates are out of limits the data for this sample are flagged as estimates or estimated detection limits.

#### 3. LABORATORY DATA VALIDATION

#### 3.1 SURFICIAL SOIL INORGANICS (PHASE I, TOTAL METALS)

This section summarizes Quality Assurance of surficial soil inorganics data according to EPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988).

#### 3.1.1 ANALYTICAL METHODS

Soil samples were analyzed for total metals according to EPA methods for flame atomic absorption spectraphotometry. Samples SS-67, SS-68, and SS-57 were analyzed for arsenic by hydride generation flameless AA because the absorbance results for these samples were below the range of standard absorbances for flame atomic absorption.

#### 3.1.2 SAMPLE HANDLING

The laboratory reported that they received and discarded broken sample bottles labeled MW6-S-1 and MW9-S-1. The Sample Custody Report incorrectly states that these samples were not collected. The bottles were broken in transit from Parametrix to the ASARCO laboratory and no analyses were performed on the samples.

#### 3.1.3 HOLDING TIMES

The sample holding times for metals were a little more than three months, thus exceeding the 28-day requirement for mercury holding time. Mercury results may be biased low and were flagged as estimates (J or N). All surficial soil samples were analyzed within the six-month holding time limit for all other metals analyses.

#### 3.1.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal analyzed. The linearity of the analytical curves served as measures of initial calibration demonstrating that the instrument was capable of producing acceptable quantitative data at the beginning of the analysis run. Continuing calibration checks were generally performed once every 10 samples and verified that the initial calibrations remained valid.

<u>Correlation Coefficients</u>: EPA Functional Guidelines (EPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. The correlation coefficients for cadmium (0.993) and lead (0.994) were less than the quality control limit, thus all surficial soils results for these metals were flagged as estimates (J or N). One of the standard curves for mercury analysis had a correlation coefficient of 0.979 and mercury results derived from this curve were also flagged as estimates.

Initial and Continuing Calibration Verification: Spot checks of the calibration percent recoveries verified that values re-calculated from raw data agreed with the values reported by the laboratory. Generally, all initial and continuing calibration recoveries were within the quality control limits of 90 to 110 percent of the true value. Two continuing calibration verification percent recoveries were 114.5 percent in the February 11 analysis of antimony. Antimony results for samples SS-28, SS-40, SS-47, SS-48, SS-36, SS-6, and SS-3 may be biased high and were flagged as estimates (J).

#### 3.1.5 BLANKS

Blank Frequency: Reagent blanks were generally tested at a frequency of at least one per twenty samples as specified in the ASARCO RI Program QA Plan (Parametrix 1986). Only three reagent blanks were analyzed with arsenic samples tested on February 10 and no reagent blanks were analyzed with the arsenic analysis on February 12. No field blanks were collected due to the matrix of the samples.

Blank Contamination: All reagent blank metals results were reported as less than the detection limits. A review of the raw data confirmed that these results were accurately reported.

#### 3.1.6 LABORATORY CONTROL SAMPLES

Nine laboratory control samples were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. One check sample was run at the beginning and one or more check samples were run at the end of each analysis for each metal. All laboratory control sample results were within the certified ranges for those samples. A review of the raw data confirmed that these results were accurately reported.

#### 3.1.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: Laboratory duplicate analysis frequency met contract requirements of at least one per 20 samples.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data confirmed these results.

#### 3.1.8 MATRIX SPIKE SAMPLE ANALYSIS

Spike Analysis Frequency: Matrix spike analysis frequency generally met the contract requirement of at least one per 20 samples for all metals tested. The laboratory reported that the spike chosen was unsuitable for the range of sample values in the February 10 arsenic analysis by flame atomic absorption, thus spike recovery results were not reported for this analysis. The absence of spike recovery information for arsenic analysis of these samples did not substantially affect sample data usefulness

because calibration checks demonstrated the accuracy of the measurement methodology.

<u>Spike Recovery</u>: All spike sample recoveries reported were within the  $\pm 25$  percent quality control limit indicating acceptable digestion and measurement of metals in the sample matrix. The laboratory reported that the spike was unsuitable for several sample analyses of arsenic, copper, lead, silver and zinc. A post digestion spike was analyzed for each sample having unsuitable spikes and all post digestion spike recoveries were within the  $\pm 15$  percent control limit. These results were confirmed by checking the raw data and recalculating percent recoveries.

#### 3.1.9 FURNACE ATOMIC ABSORPTION QC

Furnace AA analyses were not performed on Phase I total metals surficial soil samples.

#### 3.1.10 SAMPLE RESULT VERIFICATION

Photocopies of raw data forms were provided for the atomic absorption analysis of surficial soils samples. Results were also reported for standards that were used to plot standard curves of absorbances at known concentrations. When the absorbance reading for a sample was outside the range of absorbance values represented by the standard curve, the sample was run again at reduced sensitivity and compared with a standard curve of higher analyte concentrations. Copies of the instrumentation logs and standard operating procedures were also included with the laboratory data package. An examination of the raw data did not detect any anomalies and verified that there were no transcription or data reduction errors.

#### 3.1.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Four field duplicate samples were analyzed for total metals, thus meeting the requirement of one field duplicate per twenty samples.

Relative Percent Differences: The relative percent differences (RPDs) between duplicate sample results were generally less than 25 percent indicating high overall precision in sample collection and analysis. The RPD between antimony results for samples SS-31A and SS-31B was 36 percent. Field duplicate results were not used to quality sample data.

#### 3.2 SURFICIAL SOIL INORGANICS (PHASE I, EP TOXICITY METALS)

This section summarizes Quality Assurance of surficial soil Extraction Procedure Toxicity (EP Tox) metals data according to EPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988).

#### 3.2.1 ANALYTICAL METHODS

Surficial soil samples were and analyzed for arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver in accordance with EPA's Toxic Extraction Procedure (EPA Method 1310). Following acid extraction, samples were analyzed by flame atomic absorption spectraphotometry. Samples that registered  $\leq 5$  ug/ml arsenic by flame atomic absorption were re-analyzed for arsenic by colorimetry.

The laboratory analyst inadvertently performed an acid extraction analysis of copper and zinc, metals not included on the list of EP Tox metals. The laboratory amended the final EP Tox results to include copper and zinc data.

#### 3.2.2 SAMPLE HANDLING

All samples were handled properly as specified in the project QA plan.

#### 3.2.3 HOLDING TIMES

The sample holding times for EP Tox metals varied from 48 days for mercury analysis of some samples to just over three months for the analysis of selenium and arsenic in other samples. The 28-day holding time limit for mercury was exceeded for all EP Tox samples. Mercury results may be biased low and were flagged as estimates (J or N). All surficial soil samples were analyzed within the six-month holding time requirement that applies to all other metals analyzed.

#### 3.2.4 CALIBRATION

Calibration Frequency: Generally, a blank and at least three standards were used to establish analytical curves on each day of analysis for each metal analyzed. The one exception was when a blank and only two standards were used to generate a standard curve for silver. This departure from EPA guidelines was judged to have no affect on sample results because silver was not detected in any EP Tox sample analyzed. The linearity of standard curves served as measures of initial calibration demonstrating that the instrument was capable of producing acceptable quantitative data at the beginning of the analysis. Continuing calibration checks were generally performed once every 10 samples and verified that the initial calibrations remained valid.

<u>Correlation Coefficients</u>: EPA Functional Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. The correlation

coefficient for cadmium (0.983) was less than the quality control limit, thus all cadmium results were flagged as estimates (J or N).

Initial and Continuing Calibration Verification: A review of the calibration percent recoveries verified that values re-calculated from raw data agreed with the values reported by the laboratory. All initial and continuing calibration recoveries were within the certified ranges for each calibration standard.

#### 3.2.5 BLANKS

Blank Frequency: Reagent blanks were analyzed at a frequency of at least one per twenty samples as specified in the ASARCO RI Program QA Plan (Parametrix 1986). No field blanks were collected due to the matrix of the samples.

Blank Contamination: All reagent blank EP Tox metals results were reported as less than the detection limits. A review of the raw data confirmed that these results were accurately reported.

#### 3.2.6 LABORATORY CONTROL SAMPLES

Four laboratory control samples (reference samples) were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. One reference sample was run at the beginning and again at the end of each metal analysis. All laboratory control sample results were within the certified ranges for those samples. A review of the raw data confirmed that these results were accurately reported.

#### 3.2.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: Three laboratory duplicate samples were analyzed for 68 samples for a duplicate frequency of one per 23 samples for each metal tested. These duplicate frequencies did not meet the minimum of one duplicate per 20 samples called for in the Program QA Plan (Parametrix 1986). The low duplicate frequency rates were judged to be minor departures from protocol and no action was taken to qualify results.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data confirmed these results.

#### 3.2.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spike Analysis Frequency</u>: Three spiked samples were analyzed for 68 samples for a spike frequency of one per 23 samples for each metal tested. These spike frequencies did not meet the minimum of one duplicate per 20 samples called for in the Program QA Plan (Parametrix 1986). The low spike frequency rates were judged to be minor departures from protocol and no action was taken to qualify results.

<u>Spike Recovery</u>: All spike sample recoveries reported were within the  $\pm 25$  percent quality control limit indicating acceptable digestion and measurement of metals in the sample matrix. These results were confirmed by reviewing raw data and re-calculating recoveries.

#### 3.2.9 FURNACE ATOMIC ABSORPTION QC

Furnace AA analyses were not performed on Phase I EP Tox metals surficial soil samples.

#### 3.2.10 SAMPLE RESULT VERIFICATION

Photocopies of raw data forms were provided for the atomic absorption analysis of surficial soils samples. Results were also reported for standards that were used to plot standard curves. Copies of the instrumentation logs and standard operating procedures (SOPs) were also included with the laboratory data package. An examination of the raw data did not detect any anomalies and verified that there were no transcription or data reduction errors.

#### 3.2.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Four field duplicate samples were analyzed for total metals, thus meeting the requirement of one field duplicate per twenty samples.

Relative Percent Differences: The relative percent differences (RPDs) between duplicate sample results were generally less than 25 percent indicating high overall precision in sample collection, extraction and analysis. The RPDs between samples SS-63A and SS-63B were 90 percent for arsenic and 120 percent for barium. RPDs for arsenic and barium calculated for the other three duplicates were less than 25 percent. RPDs for mercury ranged from 30 to 89 percent for three duplicates and RPDs for lead were high for two duplicates. These results reflect the high variability of some extractable metals in the marine sediments at the ASARCO Tacoma site. Field duplicate results were not used to quality sample data.

#### 3.2.12 pH

The laboratory measured the pH of each sample with an Orion Model 601A digital pH meter. One reference sample (WP 384-2) was analyzed daily and all results were within 0.1 pH unit of the true value. Three laboratory duplicate samples were tested and all results were within 0.2 pH units of the duplicated sample indicating acceptable overall precision in sample collection and analysis.

# 3.3 SURFICIAL SOIL INORGANICS (PHASE II; TOTAL METALS, EP TOXICITY METALS, AND ARSENIC)

This section summarizes Quality Assurance of Phase II surficial soil inorganics laboratory data according to Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988).

#### 3.3.1 ANALYTICAL METHODS

Soil samples were analyzed for total metals according to EPA methods for flame atomic absorption spectraphotometry. A number 10 ASTM testing sieve was used to remove coarse fragments >200 mm diameter before analyses and the percent coarse fragments by dry weight were calculated. Samples were analyzed for EP Tox metals in accordance with Toxic Extraction Procedure protocols (EPA Method 1310). Samples that registered  $\leq 1$  ug/ml arsenic by flame atomic absorption were reanalyzed for arsenic by colorimetry.

#### 3.3.2 SAMPLE HANDLING

All samples were handled properly as specified in the project QA plan.

#### 3.3.3 HOLDING TIMES

The sample holding times between collection and mercury analyses were 49 to 50 days for total mercury and 46 to 47 days for EP Tox mercury, thus exceeding the 28-day holding time requirement. All positive mercury results were flagged as estimates (J) and all negative mercury results were flagged as detection limit estimates (N). All other metals analyses were completed well within the six-month holding time limit.

#### 3.3.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal tested. A blank and at least four standards were used to establish analytical curves for mercury analyses.

<u>Correlation Coefficients</u>: EPA Functional Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. All standard curve correlation coefficients met or exceeded the 0.995 minimum.

Initial and Continuing Calibration Verifications: A review of the calibration percent recoveries verified that values re-calculated from raw data agreed with the values reported by the laboratory. The initial calibration verification (ICV) percent recoveries for both selenium analyses (113.5 percent) exceeded the 110 percent quality control limit in the EP Tox analysis. Positive EP Tox selenium results for samples SS2-01 and SS2-22 may be biased high and were flagged as estimates (J). The first

continuing calibration verification sample tested for selenium had a recovery (87.5 percent) less than the 90 percent minimum. Negative EP Tox selenium results for SS2-02 and SS2-15 may be biased low and were flagged as detection limit estimates (N).

#### 3.3.5 BLANKS

Blank Frequency: Reagent blanks were analyzed at a frequency of at least one per twenty samples as specified in the program QA plan. The laboratory also analyzed an initial calibration blank (ICB) at the beginning of each analysis batch and one continuing calibration blank (CCB) every 10 samples. No field blanks were collected due to the matrix of the samples.

Blank Contamination: All blank results were reported as less than the detection limits indicating laboratory contamination did not significantly influence sample results. A review of the raw data confirmed that blank results were accurately reported.

#### 3.3.6 LABORATORY CONTROL SAMPLES

Seven laboratory control samples (reference samples) were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. At least one reference sample was tested at the beginning and again at the end of each sample analysis. The percent recoveries of chromium in two analyses of the laboratory control sample NBS-2704 (Buffalo River Sediment) (76 percent) were less than the 80 percent control limit in the total chromium analysis.

The laboratory noted that the "soft digestion" procedure was not amenable to total extraction of chromium from this matrix. Recoveries of total chromium in the laboratory control sample MBS-1645 (River Sediment) were within control limits as were matrix spike recoveries for total chromium, thus no action was taken to qualify sample results. All other laboratory control sample results were within the certified ranges for those samples. A review of the raw data confirmed that these results were accurately reported.

### 3.3.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: Two laboratory duplicate samples were analyzed for total metals and EP Tox metals along with the 27 surficial soil samples. Two laboratory duplicate samples were also run with the 21 arsenic depth study samples. These duplicate frequencies exceeded the minimum of one duplicate per 20 samples specified in the Program QA Plan (Parametrix 1986).

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data confirmed these results.

### 3.3.8 MATRIX SPIKE SAMPLE ANALYSIS

Spike Analysis Frequency: Two pre-digestion matrix spike samples were generally analyzed for total metals and EP Tox metals along with the 27 surficial soil samples. Two pre-digestion matrix spikes and one post-digestion matrix spike were analyzed along with the 21 arsenic depth study samples. During the EP Tox analysis of barium, the laboratory ran two post-digestion spikes, but no pre-digestion spikes. One post-digestion spike was run with the copper EP Tox analysis in addition to the pre-digestion spikes. Sample concentrations of total copper, total arsenic, and total lead exceeded the spike amount by more than a factor of four, thus the laboratory ran post-digestion spikes but didn't run pre-digestion spikes for these analyses. Two post-digestion spikes were also run for total antimony in addition to two pre-digestion spikes. These tests were judged to satisfy the matrix spike frequency requirements.

Spike Recovery: The matrix spike recovery of total antimony was 45 percent for sample SS2-01 and 28.5 percent for SS2-21. These results indicate that total antimony sample results may be biased low. All positive total antimony results were flagged as estimates (J) and negative total antimony results were flagged as detection limit estimates (N). The matrix spike recovery of arsenic in sample SS2-05A (127.5 percent) exceeded the 125 percent quality control limit, thus all positive arsenic results from the depth study samples may be biased high and were flagged as estimates (J).

# 3.3.9 FURNACE ATOMIC ABSORPTION QC

Furnace AA analyses were not performed on any Phase II surficial soil samples.

#### 3.3.10 SAMPLE RESULT VERIFICATION

Photocopies of all raw data forms were provided for the total metals, EP Tox metals, and arsenic depth study Phase II soil samples. Results were also reported for standards that were used to plot standard quantitation curves. Copies of the instrumentation logs and standard operating procedures (SOPs) were also included with the laboratory data package.

The total mercury result for sample SS2-17 was incorrectly reported as 6.8 ppm. The laboratory sent a correction sheet with the correct result of 13.6 ppm. The laboratory also sent a correction sheet to change the total antimony result for SS2-09 from 13 ppm to <13 ppm. An examination of the raw data verified that there were no other transcription or data reduction errors.

# 3.3.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Two field duplicate samples were analyzed for total metals and two field duplicates were analyzed for EP Tox metals, thus meeting the QA plan objective of one field duplicate per twenty samples. No field duplicates were collected during the arsenic depth study.

Relative Percent Differences (RPDs): The RPDs between field duplicate samples SS2-03 and SS2-26 were 99 percent for total copper, 121 percent for total mercury, 45.3 percent for total zinc, and exceeded the CRQL for total antimony. The RPD between field duplicate samples SS2-15 and SS2-27 was 63.6 percent for total antimony. The low overall precision indicated by these high RPDs was probably due to the variability of metals in the surficial soils at sites sampled because laboratory duplicate RPDs were all less than 20 percent. The RPDs for the field duplicate EP Tox samples were all less than 25 percent except for copper in samples SS2-03 and SS2-26 (92 percent). The high RPD for EP Tox copper may indicate a high degree of variability in extractable copper in the surficial soils at the site. Field duplicate results were not used to quality sample data.

#### 3.4 SURFICIAL SOIL ORGANICS

This section summarizes Quality Assurance of surficial soil organics data according to Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988, USEPA 1985).

### 3.4.1 ANALYTICAL METHODS

Moisture content was analyzed according to EPA Method 160.3 and reported in percent. PCBs were analyzed according to EPA Method 3540 and reported in mg/kg. Semi-volatile organics on the Hazardous Substance List (HSL) were extracted and analyzed by GC/MS according to protocols established in USEPA Contract Laboratory Program (CLP) (USEPA 1988). Semi-volatile results were reported in mg/kg on both a dry-weight basis and as-received basis.

### 3.4.2 HOLDING TIMES

The holding times to extraction for PCB analyses of these samples ranged from eight to 20 days for surficial soils and 43 to 53 days for bore-soil samples. EPA Functional Guidelines (USEPA 1985) state that samples must be extracted within seven days for PCB and semi-volatile organics water samples. In the absence of statistically determined holding times for soil matrix samples, the water matrix holding times were applied to these soil samples. All PCB results were flagged as estimates (J or N). Holding times for the extraction (seven days) and analysis (40 days) of semi-volatile organics were within control limits for all surficial soil samples. Bore-hole soil sample holding times from collection to extraction were 36 to 46 days for semi-volatile organics, thus all data for these samples will be flagged as estimates (J or N).

# 3.4.3 GC/MS TUNING

Mass Calibration: Standard decafluorotriphenylphosphine (DFTPP) mass calibration was performed appropriately and reported on Form V.

<u>Ion Abundance</u>: All ion abundance criteria were met for each mass calibration. The data presented on each Form V was compared with the corresponding mass listing. No transcription or calculation errors were discovered and the appropriate number of significant figures were reported. These results demonstrated that instrument tuning and performance met EPA criteria to ensure mass resolution and compound identification.

<u>Calibration Frequency</u>: Mass calibration was performed within 12 hours of each sample analysis. The 12-hour GC/MS tuning frequency requirement was exceeded during the analysis of re-injected samples SS-MW4-S-1, SS-MW5-S-1, and the matrix spike sample. This was regarded as a minor departure from laboratory protocol and no action was taken to qualify results.

#### 3.4.4 CALIBRATION

<u>Instrument Calibration</u>: Results of the initial calibration checks demonstrated that the GC/MS instrument was capable of producing acceptable quantitative data. Continuing calibration checks performed on each day of sample analysis documented satisfactory maintenance and adjustment of instruments.

Average Relative Response Factors: Average relative response factors (RRFs) were calculated for each semi-volatile compound on the target compound list (TCL) using five calibration points. All system performance check compounds (SPCCs) had average RRFs greater than or equal to the 0.05 control limit in all initial and continuing calibrations. The percent differences between average RRFs reported for initial and continuing calibrations were less than the 25 percent maximum for all calibration check compounds (CCCs). These results were verified by re-calculating one or more average RRFs and percent differences for each initial and continuing calibration. No errors were detected.

Relative Standard Deviations: Relative standard deviations (RSDs) of response factors were calculated for each semi-volatile compound on the TCL. All calibration check compound RSDs were less than or equal to the 30 percent control limit. Recalculation of one or more RSDs for each initial calibration detected no errors and verified RSD values reported by the laboratory.

<u>Calibration for PCB Analysis</u>: The laboratory submitted calibration tables that list the response factors for each peak generated from the initial injection of four standards. Calibration response factors were calculated by dividing the amount of standard injected by the chromatogram peak height. Calibration linearity was checked by calculating the percent relative standard deviations (RSDs) of response factors for the four standards. RSDs ranged form 15 to nearly 50 percent. These results, along with holding time limit violations contributed to the decision to flag PCB results as estimates.

#### **3.4.5 BLANKS**

<u>Laboratory Blanks</u>: One method blank sample was analyzed for each set of extracted samples resulting in a frequency that exceeded the one-per-twenty-samples frequency called for in the project QA plan. No field blanks were analyzed because soil matrix blanks are not available.

Blank Contamination: No target semi-volatile organic compounds or PCBs were detected in any method blanks indicating analytical procedures did not introduce significant contamination to any samples. Blank results were verified by inspecting chromatograms and quantitation reports.

Blank Quantitation Limits: The compound quantitation limits reported for method blank analyses were generally consistent with sample analyses and matched the Contract Required Quantitation Limits (CRQLs) listed in CLP.

#### 3.4.6 SURROGATE RECOVERY

BNA Surrogate Recovery: Laboratory performance on each semi-volatile organics sample was established by spiking the sample with six surrogate compounds. Surrogate recoveries were generally within control limits established in the CLP.

Sample SS-70 was diluted by a factor of ten and re-analyzed following low surrogate recoveries in the original analysis. Recoveries of five out of six surrogate compounds were below control limits in the re-analysis, including a surrogate recovery of less than ten percent for 2,4,6-tribromophenol. These results indicated that there may have been semi-volatile compounds present in the sample that were not detected, thus all non-detect results for sample SS-70 were flagged as unusable (R).

Surrogate recovery of terphenyl-d14 in samples SS-69, SS-61, SS-19, and SS-20; and 2,4,6-tribromophenol in sample SS-59 exceeded control limits. All other surrogate recoveries were within limits in these samples thus no action was taken to qualify results.

Surrogate recovery of phenol was less than the lower control limit in sample SS-MW5-S-1. Because the surrogate recovery was less than 10 percent, all positive results for sample SS-MW5-S-1 were flagged as estimates (N) and all negative results were flagged as unacceptable (R).

Surrogate recovery of nitrobenzene-d5 in sample SS-21 was reported as zero, thus all positive semi-volatile results were flagged as estimates (N) and negative results were flagged as unusable (R) for this sample.

PCB Surrogate Recovery: Laboratory performance on each PCB sample was established by spiking the sample with the surrogate compound oxychlordane. Recovery of oxychlordane was less than the control limit for samples SS-69, SS-56, SS-42, SS-36, and SS-37. PCBs were not detected in these samples, thus no action was taken to qualify results based on the surrogate recoveries.

Method Blank Surrogate Recovery: All semi-volatile surrogate recoveries were within control limits for method blank analyses. Surrogate recovery of oxychlordane was within control limits for all method blanks except Method Blank 314A. No action was taken to qualify PCB results based on the low surrogate recovery.

<u>Calculations</u>: Surrogate recovery results were verified by comparison with quantitation reports and no transcription or calculation errors were detected.

#### 3.4.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

Spike Recoveries: Matrix spike (MS) and matrix spike duplicate (MSD) recoveries were generally within established advisory limits indicating acceptable long-term accuracy of the analytical method. MS and MSD recoveries of pyrene were below

zero for samples documented in Memorandum S6, thus positive pyrene results for these samples were flagged as estimates (N), and negative pyrene results were flagged as unusable (R). Matrix spike duplicate recovery of pyrene exceeded the upper control limit for samples reviewed in Memorandum S3, thus positive results for these samples were flagged as estimates (N).

No more than three of the eleven MS or MSD recoveries were out of control limits for any batch of samples, and the spike compounds that did have high recoveries were not detected in associated samples. For these reasons, no further action was taken to qualify semi-volatile data based on MS/MSD recoveries. The laboratory reported that MS/MSD results were not applicable to Memorandum S2 samples due to sample dilutions necessitated by matrix effects. All PCB (arochlor 1242 and arochlor 1260) MS and MSD recoveries were within the control limits of 80 to 100 percent.

Relative Percent Differences (RPDs): The relative percent differences between MS and MSD recoveries were generally within established advisory limits indicating acceptable long-term precision of the analytical method. One of eleven RPDs exceeded control limits for samples reviewed in Memoranda S1 and S3. All RPDs for PCB MS/MSD recoveries were within the 10 percent control limit for surficial soil samples. The RPDs between matrix spiked and matrix spiked duplicate samples exceeded the control limits for arochlor 1242 and arochlor 1260 in bore-hole soil samples. No action was taken to qualify sample data based on these results.

<u>Calculations</u>: MS/MSD results were verified by comparing them to quantitation reports and re-calculating percent recoveries and RPDs. No transcription or calculation errors were detected.

Matrix Spike Frequency: MS/MSD analyses were performed for each semi-volatile organics extraction batch, thus exceeding the one-matrix-spike-per-twenty-samples frequency specified in the project QA plan.

# 3.4.8 FIELD DUPLICATES/REPLICATES

<u>Duplicate Analyses</u>: Field duplicate samples were collected and analyzed for an indication of overall precision, including both field and laboratory precision. Soil samples typically show greater variance than water samples due to difficulties associated with collecting identical samples.

Relative Percent Differences: The RPDs between field duplicate analyses of moisture content, PCBs and semi-volatile organics were generally less than 35 percent indicating high field and analytical precision. However, the RPDs calculated for the analyses of samples SS-31A and SS-31B exceeded 35 percent for nine semi-volatile organic compounds. The high RPDs indicated low overall precision, but no quality control limits were applied to field duplicate results. These results may reflect the variability of semi-volatile organic compounds in the soils at this sampling site.

<u>Duplicate Frequency</u>: Four field duplicate samples were collected for 74 total surficial soil samples, thus exceeding the one-duplicate-per-twenty-samples frequency specified in the project QA plan.

## 3.4.9 INTERNAL STANDARDS PERFORMANCE

Internal Standard Areas: Sample matrix interference resulted in standard areas that did not meet quality control criteria indicating that GC/MS sensitivity and response was not stable during every run. In many cases the sample was diluted, re-injected and re-analyzed resulting in acceptable internal standard areas. When the re-analysis resulted in internal standards that were still out of limits, compounds associated with these standards were flagged as estimates (J or N). Other samples were not re-analyzed and associated results were flagged as estimates.

Internal standard area data was improperly retrieved by the computer program for one of the standards in a few instances. The laboratory sent corrected forms for these samples that demonstrated internal standard areas were within control limits. Internal standard areas were verified by comparing the Internal Standard Area Summary Forms to quantitation reports and no transcription errors were detected.

Retention Times: The retention times of internal standards did not vary more than 30 seconds from the associated calibration standard.

### 3.4.10 TARGET COMPOUND IDENTIFICATION

Relative Retention Times: Inspections of mass spectra confirmed that semi-volatile target compound relative retention times (RRTS) were within 0.06 RRT units of their corresponding standard RRTs.

Mass Spectra Criteria: Comparisons of the presence and relative intensity of ion peaks between sample and standard spectra verified semi-volatile target compound identifications.

<u>PCB Identification</u>: Comparisons of retention times and relative peak height ratios between sample and standard chromatograms qualitatively verified arochlor identifications.

# 3.4.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Compound Ouantitation: Raw data was examined to verify the correct calculation of all sample results reported by the laboratory. Our review verified that the correct internal standards, quantitation ions, and response factors were used to quantitate each compound. Results were re-calculated and the only calculation or transcription error detected was in the result reported for fluoranthene in sample SS-57. The laboratory sent a corrected results sheet resolving the discrepancy.

Detection Limits: Detection limits were correctly adjusted to reflect sample dilutions.

### 3.4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory conducted a mass spectral search of the NBS library and reported the estimated quantities for the 15 largest semi-volatile peaks which were not surrogate, internal standard, or TCL compounds, but which had areas greater than 10 percent of the area of the nearest internal standard. Positive results for biphenyls, dibenzothiophene, dimethylaniline, 1-methyl(2-methyl ethyl)benzene, and methylphenanthrenes were reported in the final results and flagged by the laboratory as estimates. Other tentatively identified compounds (TICs) were not listed as compounds of interest in the ASARCO RI Sampling and Analysis Plan and were not reported in the final results.

All contractually required peaks were library searched and the tentative identifications were judged to be acceptable. No TICs of interest were detected in any of the method blanks.

### 3.5 SUBSURFACE SOIL AND SLAG INORGANICS (PHASE I)

This section presents an evaluation of the subsurface soil and slag inorganics data.

### 3.5.1 ANALYTICAL METHODS

Appropriateness of Testing: Because of limited sample volume, extractable metals testing (EP Toxicity) was not performed. Other testing was performed in accordance with the Sampling and Analysis Plan. Most metals were analyzed using flame atomic absorption technique. Arsenic and selenium were analyzed using hydride generation technique. Mercury was analyzed using cold vapor atomic absorption technique. The specific methods used are listed in Table 1.

Reporting of Data: The data were reported in an acceptable format. The appropriate units of measurement were used.

#### 3.5.2 SAMPLE HANDLING

Sample Collection: Samples collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

Sample Handling: Upon collection of each sample, the sample number, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.5.3 HOLDING TIMES

In general, samples were analyzed within the prescribed holding times. Mercury analyses were conducted beyond the suggested holding time of 28 days. Because this holding time is only specified for water samples, the data are judged acceptable and presented without qualification.

#### 3.5.4 CALIBRATION

<u>Instrument Calibration</u>: Instruments were calibrated each time a batch of samples was run.

Continuing Calibration: In general, sufficient continuing calibration checks were performed. Sufficient checks were not performed for analysis of cadmium on January 25, 1988 (12 samples run between checks), analysis of arsenic on February 1, 1988 (12 samples run between checks), and analysis of selenium on February 4, 1988 (19 samples run between checks). Because appropriate blank, spike, and duplicate samples were generally analyzed at the conclusion of these runs, the results were judged to be acceptable.

<u>Standard Calibration</u>: The instruments were calibrated with the correct number of standards. These were ASARCO SLC standards.

<u>Calibration Range</u>: In general, the samples analyzed were within the calibrated range of the instrument, Mercury analyses performed on samples MW-4, S-2 and MW-6, S-3 were outside the calibrated range. These results were qualified as estimates.

<u>Calibration Verification</u>: In general, calibration verifications were within the acceptable range (90 to 110 percent). Calibration verification results were outside the acceptable range for analysis of chromium on January 25, 1988; arsenic on February 1, 1988; and selenium on February 4, 1988. However, these results were within the ASARCO SLC acceptable range of 2 standard deviations. Therefore, the results were judged to be acceptable.

#### 3.5.5 BLANKS

Laboratory Blanks: Appropriate blank samples were analyzed.

Blank Contaminants: No contamination of blanks was detected.

Field Blanks: No field blanks were analyzed.

### 3.5.6 LABORATORY CONTROL

EPA control samples were analyzed routinely. Analysis of these samples was within acceptable control limits (80 to 120 percent).

### 3.5.7 DUPLICATE SAMPLES

<u>Duplicate Samples</u>: The number of duplicate samples analyzed was acceptable. The laboratory analyzed two duplicate samples for each parameter.

Relative Percent Difference: The calculated RPDs were within acceptable control limits (20 percent).

#### 3.5.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spiked Samples</u>: The number of spiked samples analyzed was acceptable. The laboratory analyzed two spiked samples for each parameter tested except selenium for which one spike was analyzed.

Spike Recovery: Spike recoveries were within the acceptable 75 to 125 percent range.

# 3.5.9 INSTRUMENT QUALITY CONTROL

Sufficient instrument quality control analyses were performed.

### 3.5.10 SAMPLE RESULT VERIFICATION

<u>Detection Limits</u>: The detection limits achieved were acceptable. The sample results are attached.

<u>Completeness</u>: For the purposes of the Interim Remedial Investigation Report and the Phase II Sampling Plans, the data are judged to be sufficiently complete.

<u>Computational Accuracy</u>: At least 10 percent of the data have been reviewed for computational accuracy. Computational accuracy was acceptable. No errors were observed.

# 3.5.11 FIELD DUPLICATES/REPLICATES

No field duplicates were analyzed.

# 3.6 SUBSURFACE SOIL AND SLAG INORGANICS (PHASE II)

This section presents an evaluation of the soil and slag inorganics data based on the EPA guidelines and EPA format.

#### 3.6.1 ANALYTICAL METHODS

Appropriateness of Testing: ASARCO SLC laboratory performed chemical analyses as specified in the Sampling and Analysis Plan. The specific methods used are presented in Table 1.

Reporting of Data: Laboratory data were presented in a format similar to that used for EPA Contract Laboratory Work. The data were reported in parts per million (ppm) for all metals except mercury which was reported as parts per billion (ppb).

#### 3.6.2 SAMPLE HANDLING

<u>Sample Collection</u>: Samples collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

<u>Sample Handling</u>: Upon collection of each sample, the sample number, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.6.3 HOLDING TIMES

There are no established guidelines for soil holding times. EPA Data Validation Guidelines suggest using water holding time requirements established under 40 CFR 136 (Clean Water Act) when evaluating sediment data. No guidance was given for soil holding times. Due to the elevated levels and stable nature of metals in a non-saturated soil matrix, we do not believe that holding times are critical to the validity of metals data produced in this study. No soil results were qualified based on sample holding times. In general, samples collected during Phase II were digested extracted and analyzed within the suggested holding times for water. Fourteen soil samples collected during Phase I were analyzed for total and EP toxicity metals as part of Phase II. Holding times for these samples were approximately one year.

#### 3.6.4 CALIBRATION

<u>Instrument Calibration</u>: Atomic Absorption instruments were calibrated before each batch of samples were tested.

Continuing Calibration: Continuing calibration standards and blanks were typically run after every ten samples and at the end of each batch of samples.

<u>Standard Calibration</u>: Atomic Absorption instruments were calibrated with a blank and at least three standards. A blank and four standards were used for mercury analyses. The results of sample analysis fell within the calibrated range of the instrument. When sample results fell outside the calibrated range, the sample was diluted until the result fell within range.

Calibration Curve Correlation Coefficients: Correlation coefficients were calculated for the calibration standards. Correlation coefficients for nickel, selenium, and zinc analyses were less than 0.995. Sample results associated with these calibration curves were flagged as estimates (J). Correlation coefficients could not be calculated for arsenic and mercury.

<u>Calibration Verification</u>: The initial calibration verification values all fell within the control limits of 90 - 110 percent or within  $\pm 2$  standard deviations of the standard concentration (ASARCO SLC criteria). Continuing calibration verification values were not calculated by the analytical laboratory.

#### 3.6.5 **BLANKS**

<u>Laboratory Blanks</u>: In general, laboratory blanks for a particular analyte were analyzed before and after each batch of samples.

Laboratory Blank Contaminants: No contamination of blanks was detected. Blank sample detection limits are listed in the raw data.

Field Blanks: No field blanks were analyzed as part of the soil quality study.

#### 3.6.6 LABORATORY CONTROL SAMPLES

EPA solid or liquid control samples and ASARCO "in-house" standards were analyzed several times per batch of samples. All aqueous laboratory control samples fell within acceptable control limits (80 to 120 percent). Solid control samples also fell within the acceptable control range.

#### 3.6.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Samples</u>: A total of seven duplicate samples were analyzed for EP toxicity metals and six duplicates were analyzed for total metals. Samples chosen for duplicate analysis covered a wide range of total metal concentrations and included both slag and soil samples. Most of the samples chosen for EP toxicity duplicate analysis did not contain detectable metal concentrations.

Relative Percent Difference (RPD): The calculated RPDs for total and EP toxicity metals analysis were within acceptable control limits for soils (35 percent) or had sample values less than 5 times the contract required detection limit.

#### 3.6.8 MATRIX SPIKE SAMPLE ANALYSIS

Spiked Samples: One spiked digest blank and one spiked sample were typically analyzed for each parameter tested.

Spike Recovery: Spike recoveries were all within the acceptable 75 to 125 percent range except for selenium. Selenium spike recoveries were consistently below 75 percent and were flagged with an "N" by the analytical laboratory. Post digestion spike recoveries for selenium were within the acceptable control limits. All selenium results above the detection limit were qualified as estimated (J). Results below the detection limit were flagged as unusable (R).

### 3.6.9 FURNACE ATOMIC ABSORPTION

<u>Lead Analysis</u>: All lead analyses for soil and slag samples were performed on a flame AA. No graphite furnace analyses were performed.

#### 3.6.10 SAMPLE RESULT VERIFICATION

No anomalies or errors were observed in the raw data. All results appear to be within the calibrated range of the atomic absorption instrument.

# 3.6.11 FIELD DUPLICATES/REPLICATES

No field duplicates or replicates were analyzed as part of the soil quality study.

# 3.7 SUBSURFACE SOIL AND SLAG ORGANICS DATA (PHASE I)

This section presents an evaluation of the subsurface soil and slag organics data.

### 3.7.1 ANALYTICAL METHODS

In general, appropriate testing was performed on the samples submitted. The Sampling and Analysis Plan included provision for analysis of several non-priority pollutant extractable organic compounds. These compounds included biphenyl, dibenzothiophene, dimethylaniline, methylphenanthrenes, methylpyrenes, and retene. Since standards for these compounds were not analyzed, their detection would depend on the mass spectrum library searches conducted as part of the work.

### 3.7.2 HOLDING TIMES

In general, samples were extracted and analyzed within the specified holding times. In two cases (samples MW-6, S-3 and MW-9, C-1), extractions were performed up to 4 days after holding times had expired. No qualification of the data was judged necessary.

# 3.7.3 GC/MS TUNING

Mass Calibration: Standard DFTPP mass calibration was appropriately performed.

Ion Abundance: The specified ion abundance criteria were met.

Calibration Frequency: In general, mass calibration was performed at the specified 12 hour frequency. In some cases, analysis was performed more than 12 hours after mass calibration was performed. Because initial and continuing calibration data for these samples are acceptable, no qualification was necessary.

#### 3.7.4 CALIBRATION

Average Relative Response Factors: The average relative response factors (RRF) were correctly calculated for initial calibrations. The RRF for 3-nitroaniline was below the required 0.05 in all analyses. These data are therefore qualified as unusable.

Relative Standard Deviations: The relative standard deviations (percent RSD) were correctly calculated for initial calibrations. The RSD was above the 30 percent guideline for 4-chloroanaline, 2,4-dinitrophenol, and 4,6-dinitro-2-methylphenol. No qualification of the data was necessary.

Relative Response Factors: The relative response factors (RRF) were correctly calculated for continuing calibration.

<u>Percent Differences</u>: The percent differences (percent D) were correctly calculated for continuing calibrations. Large percent differences were observed for 3,3-dichlorobenzi-dine, 4,6-dinitro-2-methylphenol, 4-nitroan-aline, 4-chloroanaline, 2,4,5-trichlorophenol, and 4-nitrophenol.

## 3.7.5 BLANKS

<u>Laboratory Blanks</u>: The appropriate number of laboratory blanks were prepared and analyzed. One blank sample was analyzed for each set of digested samples.

Blank Contaminants: No target compounds were detected in the blank samples.

# 3.7.6 SURROGATE RECOVERY

ABN Surrogate Control: Surrogate recoveries were within acceptable control limits.

### 3.7.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: Matrix spikes (MS) and matrix spike duplicates (MSD) calculations were performed correctly.

Spike Recoveries: In general, spike recoveries were acceptable. Specific recoveries are listed in the data.

# 3.7.8 FIELD DUPLICATES/REPLICATES

No field duplicates or replicates were analyzed as part of Phase I scope of work.

#### 3.7.9 INTERNAL STANDARDS PERFORMANCE

Retention Times: The retention times for the internal standards were acceptable.

### 3.7.10 TARGET COMPOUND IDENTIFICATION

No significant target compound detection was made. Therefore, the criteria associated with target compound identification were not applicable.

# 3.7.11 COMPOUND QUANTITATION AND DETECTION LIMITS

<u>Ouantitation</u>: Because no significant target compounds were detected, the criteria associated with quantitation were not applicable.

<u>Detection Limits</u>: The detection limits obtained were judged to be acceptable for the purposes of the Interim Remedial Investigation Preliminary Report and the Phase II Sampling Plans.

# 3.7.12 TENTATIVELY IDENTIFIED COMPOUNDS

Library Searches: The required library searches were conducted.

Blank Association: The tentatively identified compounds (TIC) detected were not associated with blanks.

### 3.8 SUBSURFACE SOIL AND SLAG ORGANICS (PHASE II)

This section presents an evaluation of the soil and slag organics data based on the EPA guidelines and EPA format.

#### 3.8.1 ANALYTICAL METHODS

Appropriateness of Testing: ASARCO SLC laboratory performed chemical analyses as specified in the Sampling and Analysis Plan. The specific methods used are presented in Table 1.

Reporting of Data: Laboratory data were presented in a format similar to that used for EPA Contract Laboratory Work. The data were reported in milligrams per kilogram (mg/kg) for all organic analytes.

<u>Sample Collection</u>: Samples collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

Sample Handling: Upon collection of each sample, the sample number, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.8.2 HOLDING TIMES

There are no established guidelines for soil holding times. EPA Data Validation Guidelines suggest using water holding time requirements established under 40 CFR 136 (Clean Water Act) when evaluating sediment data. No guidance was given for soil holding times. Samples collected for semivolatile organic analysis were generally extracted within 14 days of sample collection. However, 13 samples collected during Phase 1 were submitted for semivolatile organic analysis as part of Phase 2. Holding times for these samples was approximately one year. Results were flagged as estimated (J). Volatile aromatic compounds were typically analyzed between 7 and 14 days after sample collection.

# 3.8.3 GC/MS TUNING

Mass Calibration: Standard DFTPP and BFB mass calibration was performed appropriately.

Ion Abundance: The specified ion abundance criteria was met.

Calibration Frequency: Mass calibration was performed within 12 hours of analysis.

#### 3.8.4 CALIBRATION

Average Relative Response Factors: The average relative response factors (RRF) were correctly calculated for initial calibrations. All RRF values were above the 0.05 requirement.

Relative Standard Deviations: The relative standard deviations (RSD) were correctly calculated for initial calibrations. Benzoic acid, 2-4 dinitrophenol, and 3,3 dichlorobenzene exceeded the 30 percent RSD requirement in at least one of the initial calibration standards. None of these compounds were detected in soil and slag samples associated with the initial calibration standards. Therefore, these compounds were not qualified.

<u>Continuing Calibration</u>: Approximately ten compounds had percent differences between initial and continuing RRF greater than 25 percent in at least one of the continuing calibration standards. Only di-n-butyl- phthalate and bis(2-ethylhexyl)phthalate were detected in soil or slag samples. Results for these two compounds were flagged as estimated (J) when the percent D criteria was exceeded.

#### **3.8.5 BLANKS**

<u>Laboratory Blanks</u>: The appropriate number of laboratory blanks were analyzed. One blank sample was analyzed for each set of extracted or purged samples.

Laboratory Blank Contaminants: No target compounds were detected in any of the laboratory blanks. TPH concentrations in laboratory blanks ranged from 30 to 33 mg/kg total petroleum hydrocarbons. The detection limit for TPH was 10 to 20 mg/kg. Sample results below 5 times the detected TPH blank concentration were qualified as not detected (U).

Field Blanks: No field blanks were analyzed as part of the soil and slag study.

#### 3.8.6 SURROGATE RECOVERY

ABN Surrogate Control: Surrogate compounds were generally within the specified range. No samples had more than one surrogate outside of the specified range.

<u>VOA Surrogate Control</u>: All surrogate compounds were within the specified range.

## 3.8.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: Matrix spikes (MS) and matrix spike duplicates (MSD) calculations were performed correctly.

<u>Spike Recoveries</u>: Spike recoveries were generally within advisory limits. One MS spike for pentachlorophenol fell just outside of the advisory limits. Sample values were not qualified based on MS recoveries.

Spike Duplicates: Relative percent differences for MSD were acceptable.

# 3.8.8 FIELD DUPLICATES/REPLICATES

<u>Duplicate Samples</u>: No duplicate or replicate samples were analyzed for organic compounds.

## 3.8.9 INTERNAL STANDARDS PERFORMANCE

Internal Standard Area: Internal standard areas did not vary by more than a factor of two from the associated calibration standard. Several samples had to be reanalyzed in order to meet the internal standard area criteria.

Retention Times: The retention times for the internal standards were acceptable.

### 3.8.10 TARGET COMPOUND IDENTIFICATION

Very few target compounds were detected. Retention times and mass spectra were examined. No errors were detected.

## 3.8.11 COMPOUND QUANTITATION AND DETECTION LIMITS

No anomalies or errors were observed in the raw data.

#### 3.8.12 TENTATIVELY IDENTIFIED COMPOUNDS

Tentatively identified compounds were not reported by the analytical laboratory.

### 3.9 GROUNDWATER INORGANICS (PHASE I)

This section presents an evaluation of the groundwater inorganics data based on the EPA guidelines and EPA format.

#### 3.9.1 ANALYTICAL METHODS

Appropriateness of Testing: The laboratories conducted chemical analyses as specified in Sampling and Analysis Plan. Most metals were analyzed using flame atomic absorption. Lead was analyzed using flame atomic absorption or graphite furnace technique and selenium was analyzed using hydride generation technique. The specific methods used are listed in Table 1.

Reporting of Data: Laboratory data were presented in a format similar to that used for EPA contract laboratory work. The data were reported in the appropriate units of measurement.

### 3.9.2 SAMPLE HANDLING

<u>Sample Collection</u>: Samples collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

Sample Handling: Upon collection of each sample, the sample number, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.9.3 HOLDING TIMES

In general, samples were analyzed within the prescribed holding times. One sample (MW-3A2) was analyzed for mercury 33 days after collection (5 days beyond holding time). This datum was qualified as an estimate.

#### 3.9.4 CALIBRATION

<u>Instrument Calibration</u>: Instruments were calibrated before each batch of samples was tested.

Continuing Calibration: In general, sufficient continuing calibration checks were performed at the appropriate intervals. Sufficient continuing calibration checks were not performed for mercury analysis on November 17, 1987. In this instance, 12 samples were run without continuing calibration. Because the run was concluded with analysis of appropriate blank, spike, and duplicate samples, the analyses are judged to be acceptable.

Standard Calibration: Instruments were calibrated with the correct number of standards (3 concentrations per analysis run). EPA standard materials were used in accordance with the EPA guidelines.

<u>Calibration Range</u>: The results of sample analysis fell within the calibrated range of the instrument. The calibration ranges varied from run to run. Specific information regarding ranges can be found in the raw data.

<u>Calibration Verification</u>: In general, calibration verification fell within acceptable limits (90 to 110 percent). Calibration verification results were outside the acceptable range for analysis of barium on January 12, 1987; mercury on November 17, 1987; and selenium on January 19, 1988. Because the calibration verifications reported are within 2 standard deviations of the standard concentration (ASARCO SLC criteria), the results are judged to be acceptable. These ranges are listed in the attached data packet.

### 3.9.5 BLANKS

<u>Laboratory Blanks</u>: One blank sample per parameter per analysis run was analyzed. Because the number of samples per run varied, the frequency of blank analysis is not uniform.

Blank Contaminants: No contamination of blanks was detected. Blank sample detection limits are listed in the raw data.

<u>Field Blanks</u>: Analysis of field blanks (waters used for sampling equipment decontamination and drilling) indicated the presence of copper, cadmium, arsenic, and zinc at relatively low concentrations. At the concentrations detected, their presence is judged to be insignificant.

### 3.9.6 LABORATORY CONTROL

EPA liquid control samples were analyzed routinely. Analysis of these samples was within acceptable control limits (80 to 120 percent).

#### 3.9.7 DUPLICATE SAMPLES

<u>Duplicate Samples</u>: The number of duplicate samples analyzed is acceptable. The laboratory analyzed two duplicate samples for each parameter. The frequency of duplicate sample analysis varied.

Relative Percent Difference: In general, the calculated relative percent differences (RPD) were within acceptable control limits. One duplicate analysis for arsenic performed on January 20, 1988 (MW-13) was outside the acceptable range with -28.6 RPD (acceptable range for this sample was  $\pm 20$  percent). This result was qualified as an estimate.

#### 3.9.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spiked Samples</u>: Sufficient spiked sample analysis was performed. The laboratory analyzed two spiked samples for each parameter tested.

Spike Recovery: Spike recoveries were within the acceptable range of 75 to 125 percent.

### 3.9.9 INSTRUMENT QUALITY CONTROL

<u>Instrument Quality Control Analysis</u>: Sufficient instrument quality control analyses were performed.

Graphite Furnace Ouality Control: Lead was analyzed using graphite furnace technique. Sufficient and acceptable quality control analyses were performed.

#### 3.9.10 SAMPLE RESULT VERIFICATION

<u>Detection Limits</u>: The detection limits achieved were judged to be adequate for project requirements. The sample results are attached.

<u>Completeness</u>: For the purposes of the Interim Remedial Investigation Preliminary Report and the Phase II sampling, the data were judged to be complete.

Computational Accuracy: More than 10 percent of the data have been reviewed for computational accuracy. Computational accuracy was acceptable. No errors were observed.

# 3.9.11 FIELD DUPLICATES/REPLICATES

No field duplicates were analyzed.

### 3.10 GROUNDWATER INORGANICS (PHASE II)

This section presents an evaluation of the groundwater inorganics data based on the EPA guidelines and EPA format.

#### 3.10.1 ANALYTICAL METHODS

Appropriateness of Testing: ASARCO SLC laboratory performed chemical analyses as specified in the Sampling and Analysis Plan. The specific methods used are presented in Table 1.

Reporting of Data: Laboratory data were presented in a format similar to that used for EPA Contract Laboratory Work. The data were reported in parts per billion (ppb) for all metals except magnesium which was reported as parts per million (ppm).

#### 3.10.2 SAMPLE HANDLING

<u>Sample Collection</u>: Samples collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

Sample Handling: Upon collection of each sample, the sample number, preservative, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.10.3 HOLDING TIMES

Sample holding times met holding time requirements established under 40 CFR 136 (Clean Water Act) for metals and mercury analyses. All samples requiring preservation were preserved at the time of sample collection.

#### 3.10.4 CALIBRATION

<u>Instrument Calibration</u>: Atomic Absorption instruments were calibrated before each batch of samples were tested.

<u>Continuing Calibration</u>: Continuing calibration standards and blanks were typically run after every ten samples and at the end of batch of samples.

Standard Calibration: Atomic Absorption instruments were calibrated with a blank and at least three standards. A blank and four standards were used for mercury analyses. The results of sample analysis fell within the calibrated range of the instrument. When sample results fell outside the calibrated range, the sample was diluted until the result fell within range.

Calibration Curve Correlation Coefficients: Correlation coefficients were calculated for the calibration standards. Correlation coefficients for nickel (0.992) and lead (0.994) were less than 0.995. Samples associated with these calibration curves were flagged as estimates. Correlation coefficients could not be calculated for arsenic and selenium.

<u>Calibration Verification</u>: The initial calibration verification values fell within the control limits of 90 - 110 percent or within  $\pm$  2 standard deviations of the standard concentration (ASARCO SLC criteria). Continuing calibration verification values were not calculated by the analytical laboratory.

### 3.10.5 BLANKS

<u>Laboratory Blanks</u>: In general, laboratory blanks for a particular analyte were analyzed before and after each batch of samples.

Laboratory Blank Contaminants: Selenium was detected in blank number 3 at a concentration of 5 ppb. The detection limit for selenium was 5 ppb. Sample results for MW 1B (low tide) and MW 1B (high tide) were qualified as estimated (J) because they were below 5 times the selenium blank concentration. No other metals were detected in the blank samples. Blank sample detection limits are listed in the raw data.

Field Blanks: Two deionized water field blanks were analyzed for metals as part of the groundwater quality study. Arsenic, copper, silver, zinc, and iron were detected at concentrations ranging from 8 to 75 ppb in Blank B-7. Copper (8 ppb) and iron (50 ppb) were detected in Blank B-8. Metal concentrations in the field blanks may be due to several factors including contaminated deionized water, addition of metals from preservatives or sampling containers, and laboratory contamination. Laboratory contamination does not appear to be a problem due to the lack of detectable metals in the method blank samples. Copper and iron concentrations may be positively biased. Because of the possibility that the deionized water blanks actually contained copper and iron before sample handling, we do not believe that sample results should be qualified as not detected based on field blank results.

#### 3.10.6 LABORATORY CONTROL SAMPLES

EPA liquid control samples and ASARCO "in-house" standards were analyzed several times per batch of samples. All aqueous laboratory control samples fell within acceptable control limits (80 to 120 percent).

#### 3.10.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Samples</u>: A total of five sets of duplicate samples were analyzed for total or dissolved metals. Samples chosen for duplicate analysis covered a wide range of metal concentrations.

Relative Percent Difference (RPD): The calculated RPDs for total and dissolved metals analysis were within acceptable control limits for groundwaters (20 percent) or had sample values less than 5 times the contract required detection limit.

### 3.10.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spiked Samples</u>: Five matrix spike samples were analyzed for total or dissolved metals. The samples chosen matrix spike analysis covered a wide range of metal concentrations.

<u>Spike Recovery</u>: Spike recoveries for metals analyzed on the flame AA were all within the 75 to 125 percent control limit range. Lead was also analyzed using the graphite furnace technique. Graphite furnace spike recoveries are discussed below.

### 3.10.9 FURNACE ATOMIC ABSORPTION QC

Lead analysis: Samples which had initial lead concentrations less than approximately 25 ppb were analyzed using a graphite furnace. Total and dissolved lead in sample MW-2A were qualified as estimated (J) due to spike recoveries less than 40 percent. Dissolved lead in samples MW-2A (medium tide) and MW-3A2 (low tide) were also flagged as estimated due to low spike recoveries. In addition, ASARCO SLC laboratory flagged various lead results as "W" for samples with absorbances less than 50 percent of the past digestion spike absorbance and spike recoveries that fell outside the 85 to 115 percent range. These samples were qualified as estimates (J).

#### 3.10.10 SAMPLE RESULT VERIFICATION

No anomalies or errors were observed in the raw data. All results appear to be within the calibrated range of the atomic absorption instrument.

# 3.10.11 FIELD DUPLICATES/REPLICATES

Two field replicates were analyzed as part of the groundwater quality study. Duplicate samples were collected from MW-6 (D-6) and MW-9 (D-9). RPDs ranged from 0.8 to 154 percent. Several analytes were not detected and could not be evaluated for RPDs.

## 3.11 GROUNDWATER ORGANICS (PHASE I)

This section presents an evaluation of the groundwater organics data.

#### 3.11.1 ANALYTICAL METHODS

In general, appropriate testing was performed on the samples submitted. The Sampling and Analysis Plan included provision for analysis of several non-priority pollutant extractable organic compounds. These compounds included biphenyl, dibenzothiophene, dimethylaniline, methylphenanthrenes, methylpyrenes, and retene. Since standards for these compounds were not analyzed, their detection would depend on the mass spectrum library searches conducted as part of the work. The specific methods used are listed in Table 1.

#### 3.11.2 HOLDING TIMES

In general, samples were extracted and analyzed within the specified holding times. In one case (sample MW-8), re-extractions were performed after holding times had expired.

### 3.11.3 GC/MS TUNING

Mass Calibration: Standard DFTPP and BFB mass calibration was performed appropriately.

Ion Abundance: The specified ion abundance criteria were met.

<u>Calibration Frequency</u>: In general, mass calibration was performed within 12 hours of analysis. In one case (sample QAW3), analysis was performed approximately 30 hours after mass calibration was performed.

#### 3.11.4 CALIBRATION

Average Relative Response Factors: The average relative response factors (RRF) were correctly calculated for initial calibrations. The RRF for 3-nitroaniline was below the required 0.05 in all analyses. These data are therefore qualified as unusable.

Relative Standard Deviations: The relative standard deviations (percent RSD) were correctly calculated for initial calibrations. The compound 2,4-dinitrophenol had high percent RSD.

Relative Response Factors: The relative response factors (RRF) were correctly calculated for continuing calibration.

<u>Percent Differences</u>: The percent differences (percent D) were correctly calculated for continuing calibrations. High percent differences were observed for 3-nitroaniline, 4-nitroaniline, 4-chloroanaline, and 4-nitrophenol. These compounds are not of specific interest at the site.

### 3.11.5 BLANKS

<u>Laboratory Blanks</u>: The appropriate number of laboratory blanks were analyzed. One blank sample was analyzed for each set of extracted samples.

Blank Contaminants: No target compounds were detected in the blank samples.

#### 3.11.6 SURROGATE RECOVERY

ABN Surrogate Control: Two surrogates were outside the specified range for three samples. Two of these samples were reanalyzed with acceptable recovery. The third sample (MW-2B) was reanalyzed and low recoveries were observed again indicating a significant matrix effect. These data are not qualified.

<u>VOA Surrogate Control</u>: All surrogate compounds were within the specified range.

#### 3.11.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: Matrix spikes (MS) and matrix spike duplicates (MSD) calculations were performed correctly.

Spike Recoveries: In general, spike recoveries were acceptable. Specific recoveries are listed in the data.

# 3.11.8 FIELD DUPLICATES/REPLICATES

No replicates were analyzed as part of Phase I scope of work.

#### 3.11.9 INTERNAL STANDARDS PERFORMANCE

The retention times for the internal standards were acceptable.

#### 3.11.10 TARGET COMPOUND IDENTIFICATION

No significant target compound detection was made. Therefore, the criteria associated with target compound identification were not applicable.

# 3.11.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Ouantitation: Because no significant target compounds were detected, the criteria associated with quantitation were not applicable.

<u>Detection Limits</u>: The detection limits obtained were judged to be acceptable for the purposes of the Interim Remedial Investigation Report and the Phase II Sampling Plans.

## 3.11.12 TENTATIVELY IDENTIFIED COMPOUNDS

Library Searches: The required library searches were conducted.

Blank Association: The tentatively identified compounds (TIC) detected were not associated with blanks.

## 3.12 GROUNDWATER ORGANICS (PHASE II)

This section presents an evaluation of the groundwater organics data based on the EPA guidelines and EPA format.

### 3.12.1 ANALYTICAL METHODS

Appropriateness of Testing: ASARCO SLC laboratory performed chemical analyses as specified in the Sampling and Analysis Plan. The specific methods used are presented in Volume 1, Table B.

Reporting of Data: Laboratory data were presented in a format similar to that used for EPA Contract Laboratory Work. The data were reported in micrograms per liter (ug/l) for all organic analytes except total organic carbon (TOC) and total petroleum hydrocarbons (TPH) which were reported as milligrams per liter (mg/l).

<u>Sample Collection</u>: Samples collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

<u>Sample Handling</u>: Upon collection of each sample, the sample number, preservative, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.12.2 HOLDING TIMES

Sample holding times met holding time requirements established under 40 CFR 136 (Clean Water Act) for semivolatile organic analyses. Volatile aromatic compounds were analyzed between 7 and 14 days after sample collection exceeding the 7 day holding time requirement for all samples excluding B-16. Volatile aromatic compounds are flagged as estimated (J).

# 3.12.3 GC/MS TUNING

Mass Calibration: Standard DFTPP and BFB mass calibration was performed appropriately.

<u>Ion Abundance</u>: The specified ion abundance criteria was met.

Calibration Frequency: Mass calibration was performed within 12 hours of analysis.

#### 3.12.4 CALIBRATION

Average Relative Response Factors: The average relative response factors (RRF) were correctly calculated for initial calibrations. All RRF values were above the 0.05 requirement.

Relative Standard Deviations: The relative standard deviations (%RSD) were correctly calculated for initial calibrations. The following compounds exceeded the 30 percent %RSD requirement in at least one of the initial calibration standards: diethylphthalate, fluorene, chrysene, di-n-butylphthalate, benzidine, and dibenz(a,h)anthracene. None of these compounds were detected in groundwater samples associated with the initial calibration standards. Therefore, these compounds were not qualified.

Continuing Calibration: No continuing calibration standards were performed.

#### 3.12.5 BLANKS

<u>Laboratory Blanks</u>: The appropriate number of laboratory blanks were analyzed. One blank sample was analyzed for each set of extracted or purged samples.

Laboratory Blank Contaminants: Less than 10 ug/l of dichlorobenzene and methylene chloride were detected in the blank associated with QA-1 and QA-2. These compounds were not detected in the samples. No target compounds were detected in any of the other laboratory blanks. The laboratory blank for TPH analysis contained 0.26 mg/l total petroleum hydrocarbons. The detection limit for TPH was 0.2 mg/l. TPH results in samples B-33 and B-34 were qualified as not detected (U) because they were below 5 times the detected TPH blank concentration.

Field Blanks: One deionized water field blank (B-7) was analyzed for total petroleum hydrocarbons, volatile organic compounds, and semivolatile organic compounds. Chloroform was detected at a concentration of 31 ug/l. Chloroform was not detected in any of the groundwater samples. TPH concentration of 0.4 mg/l was detected in the field blank. TPH values in B-33, B-34, and B-37 were flagged as not detected (U).

#### 3.12.6 SURROGATE RECOVERY

ABN Surrogate Control: All surrogate compounds were within the specified range.

VOA Surrogate Control: All surrogate compounds were within the specified range.

#### 3.12.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: Matrix spikes (MS) and matrix spike duplicates (MSD) calculations were performed correctly.

Spike Recoveries: Spike recoveries were within advisory limits.

<u>Spike Duplicates</u>: In general, relative percent differences for MSD were acceptable. One MS sample had two Relative Percent Differences (RPD) just outside the advisory limits. Sample values were not qualified based on MS recoveries.

# 3.12.8 FIELD DUPLICATES/REPLICATES

No duplicate or replicate samples were analyzed for organic compounds.

### 3.12.9 INTERNAL STANDARDS PERFORMANCE

<u>Internal Standard Area</u>: Internal standard areas did not vary by more than a factor of two from the associated calibration standard.

Retention Times: The retention times for the internal standards were acceptable.

#### 3.12.10 TARGET COMPOUND IDENTIFICATION

Very few target compounds were detected. Dimethylaniline identification in groundwater was reexamined for thoroughness. Sample retention times and mass spectra agreed with the associated standard.

# 3.12.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Quantitation: No anomalies or errors were observed in the raw data.

### 3.12.12 TENTATIVELY IDENTIFIED COMPOUNDS

Tentatively identified compounds were not reported by the analytical laboratory. Upon request, the lab did report TIC compounds associated with dimethyl- aniline. This TIC data could not be thoroughly evaluated.

### 3.13 FILL LEACHING INORGANICS

This section presents an evaluation of the soil and water inorganics data based on the EPA guidelines and EPA format.

#### 3.13.1 ANALYTICAL METHODS

Appropriateness of Testing: ASARCO SLC laboratory performed chemical analyses as specified in the Sampling and Analysis Plan. The specific methods used are presented in Table 1.

Reporting of Data: Laboratory data were presented in a format similar to that used for EPA Contract Laboratory Work. The data were reported in parts per million (ppm) for all metals in soils except mercury which was reported as parts per billion (ppb). Water metals results were reported in ppb except magnesium which was reported in ppm.

### 3.13.2 SAMPLING HANDLING

Sample Collection: Sample collection techniques are described in Volume I, Appendix B. Samples were collected in clean containers supplied by I-Chem Research Company.

<u>Sample Handling</u>: Upon collection of each sample, the sample number, date, time, and sampling personnel initials were recorded on the label of each container. Samples were stored in insulated coolers packed with "blue ice" and maintained in Hart Crowser's custody until samples were shipped to ASARCO SLC laboratory.

#### 3.13.3 HOLDING TIMES

There are no established guidelines for soil holding times. EPA Data Validation Guidelines suggest using water holding time requirements established under 40 CFR 136 (Clean Water Act) when evaluating sediment data. No guidance was given for soil holding times. Due to the elevated levels and stable nature of metals in a non-saturated soil matrix, we do not believe that holding times are critical to the validity of metals data produced in this study. No soil results were qualified based on sample holding times. In general, leachate testing soil samples were extracted and analyzed within the suggested holding times for water.

Water samples were analyzed within holding times established under 40 CFR 136 except for mercury. The required holding time for mercury (28 days) was exceeded for all samples. Mercury results in water samples were flagged as estimated (J). Samples requiring preservation were preserved at the time of sample collection.

### 3.13.4 CALIBRATION

<u>Instrument Calibration</u>: Atomic absorption instruments were before each batch of samples were tested.

Continuing Calibration: Continuing calibration standards and blanks were typically run after every ten samples and at the end of each batch of samples.

<u>Standard Calibration</u>: Atomic absorption instruments were calibrated with a blank and at least three standards. A blank and four standards were used for mercury analyses. The results of sample analysis fell within the calibrated range of the instrument. When sample results fell outside the calibrated range, the sample was diluted until the result fell within range.

Calibration Curve Correlation Coefficients: Correlation coefficients were calculated for the calibration standards. Correlation coefficients for nickel (2 to 10 ppm) and zinc (20 to 100 ppm) analyses were less than 0.995. Water sample results associated with these calibration curves were flagged as estimates (J). Correlation coefficients could not be calculated for arsenic and selenium in water and mercury in soils.

<u>Calibration Verification</u>: The initial calibration verification values all fell within the control limits of 90 - 110 percent or within  $\pm 2$  standard deviations of the standard concentration (ASARCO SLC criteria). Continuing calibration verification values were not calculated by the analytical laboratory.

#### 3.13.5 BLANKS

<u>Laboratory Blanks</u>: In general, laboratory blanks for a particular analyte were analyzed before and after each batch of samples.

<u>Laboratory Blank Contaminants</u>: No contamination of blanks was detected. Blank sample detection limits are listed in the raw data.

Field Blanks: No field blanks were analyzed as part of the leachate testing study.

### 3.13.6 LABORATORY CONTROL SAMPLES

EPA solid or liquid control samples and ASARCO "in-house" standards were analyzed several times per batch of samples. All aqueous laboratory control samples fell within acceptable control limits (80 to 120 percent). Solid control samples also feel within the acceptable control range.

#### 3.13.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Samples</u>: Samples chosen for duplicate analysis covered a wide range of metal concentrations.

Relative Percent Differences (RPD): The calculated RPDs for total and EP toxicity metals analysis were within acceptable control limits for soils (35 percent) or had sample values less than 5 times the contract required detection limit. RPDs in for dissolved metal analysis were within acceptable control limits for water (20 percent).

#### 3.13.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spiked Samples</u>: One spiked digest blank and one spiked sample were typically analyzed for each parameter tested.

Spike Recovery: Spike recoveries for metals analyzed on the flame AA were all within the acceptable 75 to 125 percent range.

## 3.13.9 FURNACE ATOMIC ABSORPTION OC

<u>Lead Analysis</u>: Samples which had initial lead concentrations less than approximately 25 ppb were analyzed using a graphite furnace. All recoveries were above 40 percent. However, ASARCO SLC laboratory flagged various lead results as "W" for samples with absorbances less than 50 percent of the post-digestion spike absorbance and spike recoveries that fell outside the 85 to 115 percent range. These samples were qualified as estimates (J).

#### 3.13.10 SAMPLE RESULT VERIFICATION

No anomalies or errors were observed in the raw data. All results appear to be within the calibrated range of the atomic absorption instrument.

# 3.13.11 FIELD DUPLICATES/REPLICATES

No field duplicates or replicates were analyzed as part of the leachate testing study.

#### 3.14 SURFACE WATER INORGANICS

This section summarizes Quality Assurance of surface water inorganics data according to USEPA Laboratory Data Validation Functional Guidelines (USEPA 1988).

# 3.14.1 ANALYTICAL METHODS

Surface water samples were tested for total suspended solids (TSS) by the modified residue non-filterable gravimetric method (EPA Method 160.2) at 103 to 105°C. The modifications noted by the laboratory were the use of 47 mm diameter 0.45  $\mu$ m cellulose nitrate filters, Millipore filtering apparatus, and a 10 minute drying time in the oven.

Samples were analyzed for total and dissolved metals by flame atomic absorption spectrophotometry. The majority of samples were analyzed for load by graphite furnace atomic absorption spectraphotometry because the absorbance results were below the range of standard absorbances for flame AA. Similarly, samples that registered  $\leq 1$  ppm arsenic by flame AA were re-analyzed for arsenic by colorimetry.

Surface water samples analyzed included grab samples from seeps and secondary outfalls, and surface water samples composited by flow on the day after the storm event.

#### 3.14.2 SAMPLE HANDLING

The laboratory reported that the Round 3 TSS results for SW-1 and SW-2 were "lost in analysis", thus there are no TSS results for these two samples.

#### 3.14.3 HOLDING TIMES

Total suspended solids were analyzed within one week following sample collection. Generally, metals analyses were completed well within the six-month holding time limit and mercury was analyzed within the 28-day limit. Mercury results for the two tunnel seep samples (Seep-A and Seep-B) were flagged as estimates (J or N) because the holding time requirement was exceeded.

# 3.14.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal analyzed. The linearity of the analytical curves served as measures of initial calibration demonstrating that the instrument was capable of producing acceptable quantitative data at the beginning of the analysis run. Continuing calibration checks were generally performed once every 10 samples and verified that the initial calibrations remained valid.

Correlation Coefficients: EPA Function Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. Percent transmittance values for standards were logarithmically transformed. All standard curve correlation coefficients exceeded the 0.995 minimum.

Initial and Continuing Calibration Verification: Generally, initial and continuing calibration recoveries were within the quality control limits of 90 to 110 percent of the true value. The recovery of dissolved lead (116 percent) exceeded the 110 percent control limit for the continuing calibration verification of reference sample WP386 in the Round 1 graphite furnace analysis. This indicated the positive dissolved lead result for sample SW-1 may be biased high and provides further evidence for qualifying it as estimated (J). The initial calibration verification recovery of antimony in the laboratory control sample ERA 9916 (88 percent) was outside the +10 percent control limits in Round 3. All Round 3 positive antimony results were flagged as estimates (J) and negative antimony results were flagged as detection limit estimates (N). Spot checks of the calibration recoveries verified that values recalculated from raw data matched the results reported by the laboratory.

#### 3.14.5 BLANKS

Blank Frequency: Reagent blanks were generally tested at a frequency of at least one per twenty samples (five percent) as specified in the ASARCO RI Program QA Plan (Parametrix, 1986). In Round 1, no blanks were tested with the graphite furnace analysis of lead, thus the positive dissolved lead results for samples SW-1, SP-5, and SW-11 were flagged as estimates (J). The frequency of blank analyses during Round 2 was only four percent for mercury, cadmium, copper, and zinc; and only two percent for antimony. No blanks were tested with the flame AA analysis of arsenic, thus the arsenic results quantitated for the following samples will be flagged as estimates (J): 2056T, 2058T, 2059D, 2059T, 2068T, 2076T, and 2079T. One rinsate blank was collected in the field during each round of surface water sampling.

Blank Contamination: Metals were not detected in any surface water method blanks indicating significant contamination was not introduced to samples in the laboratory. Dissolved copper and dissolved zinc were detected in the rinsate blank collected during Round 2, but total copper and total zinc were not detected. Round 2 dissolved copper and dissolved zinc results were flagged as estimates (J) where sample concentrations were less than five times the blank concentrations. Dissolved zinc and total zinc were detected in the Round 3 rinsate blank, thus Round 3 zinc results were flagged as estimates (J) where sample concentrations were less than five times the blank concentrations. A review of the raw data confirmed these results.

Contamination of rinsate blanks probably occurred during sample filtration by the field crew prior to sample shipment. The samples were filtered in the metallurgy laboratory at the ASARCO Tacoma smelter where sample waters may have been exposed to dust containing metals.

Blank Quantitation Limits: The compound quantitation limits reported for method blank analyses were generally consistent with sample analyses and matched the Contract Required Quantitation Limits (CRQLs) listed in the CLP (USEPA 1987).

#### 3.14.6 LABORATORY CONTROL SAMPLES

Laboratory control samples were generally tested at the beginning and end of each metal analysis as a monitor of the overall performance in all steps of the analyses. All laboratory control sample percent recoveries were within the  $\pm 20$  percent quality control limits except those noted under Initial Calibration Verification. A review of the raw data confirmed that these results were accurately reported.

#### 3.14.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: Laboratory duplicate analysis frequency met or exceeded the contract requirements of at least one per 20 samples.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit indicating acceptable analytical precision. A review of the raw data verified these results.

#### 3.14.8 MATRIX SPIKE SAMPLE ANALYSIS

Spike Analysis Frequency: Matrix spike analysis frequency met or surpassed the contract requirement of one per 20 samples for all metals tested.

Spike Recovery: All spike sample recoveries were within the  $\pm 25$  percent quality control limits indicating acceptable digestion and measurement of metals in the sample matrix. These results were confirmed by checking the raw data and recalculating percent recoveries.

# 3.14.9 FURNACE ATOMIC ABSORPTION QC

Duplicate injections and furnace post-digestion spikes were analyzed to establish the precision and accuracy of the individual lead sample results. A review of the raw data verified that duplicate injections agreed within  $\pm 20$  percent relative standard deviation (RSD) for sample concentrations exceeding the CRQL (5 ppb). The raw data inspection also verified that the Furnace Atomic Absorption Scheme was followed and post-digestion spike recoveries were generally within  $\pm 15$  percent. The laboratory flagged the furnace AA dissolved lead result for sample SW-1 from Round 1 with a "W" according to CLP protocol because the spike recovery exceeded 115 percent. The laboratory also flagged Round 3 dissolved lead results for samples SW-6 and SEEP 5 with a "W" because spike recoveries were outside control limits. The total lead and dissolved lead results for Round 2 sample SW-11G were qualified with an "E" according to CLP protocol. The "W" and "E" qualifiers applied by the laboratory were changed to "J" qualifiers to comply with Data Validation Guidelines.

#### 3.14.10 SAMPLE RESULT VERIFICATION

Copies of raw data forms were provided by the laboratory for the atomic absorption analysis of surface water samples. Results were also reported for standards that were used to plot standard curves of absorbance (or transmittance) at known concentrations. When the absorbance reading for a sample was outside the range of absorbance values represented by the standard curve, the sample was run again at reduced sensitivity and compared with a standard curve of higher concentrations. Copies of the instrumentation logs and standard operating procedures were also included with the laboratory data packages. An examination of the raw data did not detect any anomalies and verified that there were no transcription or data reduction errors.

# 3.14.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: One field duplicate sample was collected during each round of 21 surface water samples, thus approximating the five percent duplicate frequency requirement.

Relative Percent Differences: The relative percent differences (RPDs) between field duplicate sample results were generally within  $\pm 20$  percent indicating high overall precision in sample collection and analysis. Total lead and total cadmium had high field duplicate RPDs for Round 1 and dissolved arsenic, total arsenic, and total zinc RPDs were high for Round 2. These results probably reflect the variability introduced by sample compositing. Field duplicate results were not used to qualify sample data.

#### 3.15 SURFACE WATER ORGANICS

This section summarizes Quality Assurance of surface water organics data according to EPA Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses (USEPA 1988, USEPA 1985).

# 3.15.1 ANALYTICAL METHODS

<u>Semi-volatiles</u>: compounds on the Hazardous Substance List (HSL) were extracted and analyzed by GC/MS according to protocols established in USEPA Contract Laboratory Program (May 1984, revised July 1985) (CLP).

<u>PCBs</u>: were analyzed according to EPA Method 3540 and reported in mg/kg (EPA WW 846 2nd ed. 1984).

#### 3.15.2 HOLDING TIMES

Holding time requirements used for these data validations are those established for water matrices under 40 CFR 136 (Clean Water Act). 1) extraction within seven days. 2) analysis within 40 days. All holding times for analyses of semi-volatile organics were within control limits except for the following:

# · Round 1

- 2 Deg A: had to be re-extracted because the first analysis did not pass laboratory QA/QC requirements. This re-extraction was 11 days past the sample collection date exceeding the 7 day sample holding time limit.
- SW-70: was re-extracted because the surrogates were forgotten in the first run. This re-extraction occurred 18 days after the sampling date also exceeding the 7 day sample holding time limit.
- Sample preparation for PCB analysis took place 11 days after sampling for all samples in Round 1. This exceeded the 7 day holding time.

# Round 2

- SW-5, SW-6, SW-10, SW-11, and SW-70 were extracted (for semi-volatile organics and PCBS) 8 days after sampling exceeding the 7 day holding time limit.
- Sample preparation for PCB analysis took place 8 days after sampling for all samples in Round 2. This exceeded the 7 day holding time.

The appropriate data will be flagged as either estimates or estimated detection limits for the above mentioned samples.

# 3.15.3 GC/MS TUNING

Mass Calibration: Standard decafluorotriphenylphosphine (DFTPP) mass calibrations were appropriately performed and reported on Form V.

<u>Ion Abundance</u>: Each mass calibration satisfied the ion abundance criteria. The data presented on each Form V compared with the corresponding mass listings. We found no transcription or calculation errors and the reported numbers contain the appropriate number of significant figures. These results demonstrated that instrument tuning and performance met EPA criteria to ensure mass resolution and compound identification.

Calibration Frequency: Performance of the mass calibrations occurred within 12 hours for all samples analyzed as required.

#### 3.15.4 CALIBRATION

Instrument Calibration: Results of the initial calibration checks demonstrated that the GC/MS instrument was capable of producing acceptable quantitative data. Continuing calibration checks performed on each day of sample analysis documented satisfactory maintenance and adjustment of the instruments.

Average Relative Response Factors: Average relative response factors (RRF) were calculated for each semi-volatile compound on the target compound list (TCL) using five calibration points. All system performance check compounds (SPCC) had average RRFs greater than or equal to the 0.05 control limit in all initial and continuing calibrations. The percent differences between average RRFs reported for the continuing calibrations were less than 25% for all calibration check compounds (CCC).

These results were verified by re-calculating the response factors (RF) for one or more of the (CCC) five point calibrations. Calculations of the average RF, RRF were verified for each of the SPCC's and CCC's. No errors were detected.

Relative Standard Deviations: Relative standard deviations (RSD) of response factors were calculated for each semi-volatile compound on the TCL. All calibration check compound RSDs were less than or equal to the 30% control limit. Recalculation of the RSDs for the SPCC and CCC compounds in the initial calibrations detected no errors.

Calibration for PCB Analysis: The laboratory submitted calibration tables that list the response factors for each peak generated from the initial injection of four standards. Calibration response factors were calculated by dividing the amount of standard injected by the chromatogram peak height. Calibration linearity was checked by calculating the percent relative standard deviations (RSDs) of response factors for the four standards. RSDs ranged from 15 to nearly 60 percent. These results along

with holding time limit violations contributed to the decision to flag PCB results as estimates.

#### 3.15.5 BLANKS

<u>Laboratory Blanks</u>: One method blank was analyzed for each round of samples. This met or exceeded the frequency of one-per-twenty-samples required by the project QA plan. One field blank (SW-70) was also analyzed for each set of samples to satisfy the project QA plan stipulations.

Blank Contamination: Blank results were verified by inspecting chromatograms and quantitation reports. None of the compounds in the Target Compound List (TCL) or PCBs were found in the blanks. However, three tentatively identified compounds (TIC) were detected in the Round 1 blank as well as in most of the samples from both rounds. Of these TIC compounds, 1,13-Tetradecadiene was detected in every sample for both sample rounds while Dichloromethane was detected in all but one sample in Round 1 (SW-6) but not in any Round 2 samples. Tetrahydrofuran was detected in the last 14 samples analyzed in Round 1 (including the method blank) but not in any Round 2 samples. Since none of the TCL compounds were found in the blank, no qualification action is deemed necessary.

Blank Quantitation Limits: The compound quantitation limits reported for method blank analyses was consistent with sample analyses and matched the Contract Required Quantitation Limits (CRQLs) listed in CLP.

#### 3.15.6 SURROGATE RECOVERY

BNA Surrogate Recovery: Laboratory performance on each semi-volatile organics sample was established by spiking the sample with six surrogate compounds. The surrogate recoveries were generally within control limits established in the CLP. The one exception was when surrogates were not included in the first analysis of SW-70 (Round 1). In the second run, nitrobenzene and 2-fluorobiphenyl were below the QA limits but on the third run all recoveries were acceptable.

<u>PCB Surrogate Recovery</u>: Laboratory performance on each PCB sample was established by spiking the sample with the surrogate compound oxychlordane. Recovery of oxychlordane was within the control limit for each sample in rounds 1 and 2.

Method Blank Surrogate Recovery: All semi-volatile and PCB surrogate recoveries were within control limits for method blank analyses.

<u>Calculations</u>: Surrogate recovery results were verified by comparison with quantitation reports and no transcription or calculation errors were detected.

# 3.15.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: MS/MSD results were verified by comparing them to quantitation reports and re-calculating percent recoveries and RPDs. No transcription or calculation errors were detected.

Matrix Spike Frequency: MS/MSD analyses were performed for each semi-volatile organics extraction batch, thus meeting the one-matrix-spike-per-twenty-samples frequency specified in the project QA plan.

<u>Spike Recoveries</u>: matrix spike (MS) and matrix spike duplicate (MSD) recoveries were within established advisory limits for semi-volatile and PCB analyses in Round 1. However, the percent recovery of 2,4-Dinitrotoluene (100%) exceeded the QA/QC limit of 96% and percent recovery of Arochlor 1242 (53%) was below the 80% limit in the matrix spike duplicate sample for Round 2. No qualifications are recommended based on MS/MSD results.

Relative Percent Differences (RPDs): The relative percent differences between MS and MSD recoveries were within established advisory limits for semi-volatiles indicating acceptable long-term precision of the analytical method. However, the RPD for Arochlor 1242 in the PCB analysis was 51% while the control limit is set at 10%. No data qualifications are appropriate based on MS/MSD results alone.

# 3.15.8 FIELD DUPLICATES/REPLICATES

<u>Duplicate Analyses</u>: A field duplicate sample was collected and analyzed for Round 1 to provide an indication of overall precision, including both field and laboratory precision.

Relative Percent Differences: There are no specific control limits established for RPDs in field duplicate samples. However, the RPD of the field duplicate was within the limits established for laboratory duplicates ( $\pm$  35%). Since field duplicates examine both field and laboratory variability, this sample is considered well within acceptable range.

<u>Duplicate Frequency</u>: One field duplicate sample was collected for the 20 surface water samples. However, since no duplicate was collected for the 5 samples in Round 2 the one-duplicate-per-twenty-samples frequency specified in the project QA plan was not met.

#### 3.15.9 INTERNAL STANDARDS PERFORMANCE

Internal Standard Areas/ Retention Times: Internal standard areas and retention times were verified by comparing the Internal Standard Area Summary Forms (Form VIII) to quantitation reports and no transcription errors were detected. The acceptable limits in standard area are no more than 100% above or less than 50%

below the 12 hour standard areas. The retention times of internal standards are to be within 30 seconds of the associated 12 hour calibration standards.

Internal standard areas and retention times were within control limits for most of the sample analyses. Only three samples had internal standard areas below the lower limit for perylene. In one case (2 Deg. A), the sample was re-extracted, injected and analyzed which resulted in acceptable internal areas. The other two samples (SP-5 and 2 Deg. B) were not re-analyzed so compounds associated with perylene are flagged as estimates.

#### 3.15.10 TARGET COMPOUND IDENTIFICATION

Relative Retention Times: Inspections of mass spectra confirmed that semi-volatile target compound relative retention times (RRTS) were within 0.06 RRT units of their corresponding standard RRTs.

Mass Spectra Criteria: Comparisons of the presence and relative intensity of ion peaks between sample and standard spectra verified semi-volatile target compound identifications.

# 3.15.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Compound Ouantitation: Raw data was examined to verify the correct calculation of all sample results reported by the laboratory. Our review verified that the correct internal standards, quantitation ions, and response factors were used to quantitate each compound. Results were re-calculated and no calculation or transcription error were detected.

<u>Detection Limits</u>: Detection limits were correctly adjusted to reflect sample dilutions.

# 3.15.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory conducted a mass spectral search of the NBS library and reported the estimated quantities for the 15 largest semi-volatile peaks which were not surrogate, internal standard, or TCL compounds, but which had areas greater than 10 percent of the area of the nearest internal standard.

As indicated in the section concerning blanks, there were a few TIC compounds that were observed in all or almost all of the samples including the blanks. These (TICs) were not listed as compounds of interest in the ASARCO RI Sampling and Analysis Plan and are not reported in the final results. All contractually required peaks were library searched and the tentative identifications were judged to be acceptable.

# 3.16 SURFICIAL MARINE SEDIMENT INORGANICS (PHASE I)

This section summarizes Quality Assurance of marine sediment inorganics data according to USEPA Laboratory Data Validation Functional Guidelines (USEPA 1988).

#### 3.16.1 ANALYTICAL METHODS

Marine sediment samples were analyzed for total metals according to EPA methods for flame atomic absorption spectrophotometry. The majority of samples were analyzed for arsenic by hydride generation flameless AA because the absorbance results were below the range of standard absorbances for flame AA.

#### 3.16.2 SAMPLE HANDLING

The laboratory reported that the custody seals on some sample containers were in a deteriorated condition upon arrival at the laboratory. The seal was broken on the jar containing sample MSM-13-7 and the jar lid was not tight.

#### 3.16.3 HOLDING TIMES

All metals analyses were completed within the six-month holding time limit for arsenic, copper, lead, and zinc.

#### 3.16.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal analyzed. The linearity of the analytical curves served as measures of initial calibration demonstrating that the instrument was capable of producing acceptable quantitative data at the beginning of the analysis run. Continuing calibration checks were generally performed once every 10 samples and verified that the initial calibrations remained valid.

<u>Correlation Coefficients</u>: EPA Functional Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. The correlation coefficients calculated for all standard curves exceeded the 0.995 minimum except those for the hydride generation flameless AA analyses of arsenic (0.984 and 0.992). All flameless AA arsenic results were flagged as estimates (J).

Initial and Continuing Calibration Verification: Generally, all initial and continuing calibration recoveries were within the quality control limits of 90 to 110 percent of the true value. The initial calibration recoveries of arsenic in standard WP886-1 (71 and 72 percent) were less than 90 percent for the hydride generation flameless AA analyses. The initial calibration standard WP886-1 was re-analyzed with recoveries of 100 percent and 80 percent. Three of the six continuing calibration verification recoveries were also outside the  $\pm 10$  percent acceptance window. These results indicate the flameless AA instrument may not have been properly calibrated for the

arsenic analysis of some samples. These calibration recoveries provided further evidence to flag flameless AA arsenic results as estimates (J). Spot checks of the calibration recoveries verified that values re-calculated from raw data agreed with the results reported by the laboratory.

#### 3.16.5 BLANKS

Blank Frequency: Reagent blanks were generally tested at a frequency of at least one per twenty samples as specified in the ASARCO RI Program QA Plan (Parametrix 1986). Only four reagent blanks (one per twenty-five samples) were analyzed for copper and no reagent blanks were run with the flame AA arsenic analysis. All flame AA arsenic results were flagged as estimates (J) due to the lack of information regarding possible sample contamination. No field blanks were collected for sediment matrix samples.

Blank Contamination: All reagent blank metals results were reported as less than the detection limits. A review of the raw data confirmed that these results were accurately reported.

#### 3.16.6 LABORATORY CONTROL ANALYSIS

Five laboratory control samples (LCS) were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. At least one of these reference samples was run at the beginning of each analysis for each metal, and additional LCSs were sometimes run at the end of an analysis. All LCS results were within the  $\pm 20$  percent recovery control limits. A review of the raw data confirmed that these results were accurately reported.

#### 3.16.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: Laboratory duplicate analysis frequency met contract requirements of at least one per 20 samples.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data confirmed these results.

# 3.16.8 MATRIX SPIKE SAMPLE ANALYSIS

Spike Analysis Frequency: Matrix spike analysis frequency generally met the contract requirement of at least one per 20 samples for all metals tested. The exception was the flame AA analysis of arsenic, for which no spike analyses were performed. All flame AA arsenic results were flagged as estimated (J) due to the lack of information regarding the effect of sample matrix on the digestion and measurement methodology.

Spike Recovery: All matrix spike recoveries were within the  $\pm 25$  percent quality control limits indicating acceptable digestion and measurement of metals in the marine sediment matrix. The laboratory reported that samples MSM-6-2 and MSM-13-1 were unsuitable for matrix spike analyses. Post digestion spike analyses were performed on both samples and the resulting recoveries were all within the  $\pm 15$  percent quality control limits.

# 3.16.9 FURNACE ATOMIC ABSORPTION QC

#### 3.16.10 SAMPLE RESULT VERIFICATION

Photocopies of raw data forms were provided by the laboratory for all atomic absorption analyses of marine sediment samples. Results were also reported for standards that were used to plot standard curves of absorbances at known concentrations. When the absorbance reading for a sample was outside the range of absorbance values represented by the standard curve, the sample was run again at reduced sensitivity and compared with a standard curve of higher concentrations. Copies of the instrumentation logs and standard operating procedures were also included in the laboratory data package. An examination of the raw data did not detect any anomalies and verified that there were no transcription or data reduction errors.

# 3.16.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Three field duplicate samples were analyzed for total metals for an average frequency of one per 33 samples. A fourth field duplicate sample was sent to another laboratory for radiological analysis. Five field duplicates were necessary to achieve the goal of one per 20 samples set forth in the ASARCO Program Quality Assurance Plan.

Relative Percent Differences: The relative percent differences (RPDs) between metals results for sample MS-4-1 and the field duplicate Rep 4 were less than 25 percent. The RPDs between arsenic results for MSM-9-5 and Rep 1 (32 percent), and between arsenic results for MSM-16-4 and Rep 3 (48 percent) exceeded 25 percent indicating low overall precision. These results suggest arsenic concentrations in the marine sediments may be highly variable, but no action was taken to qualify sample data.

# 3.17 SURFICIAL MARINE SEDIMENT INORGANICS (PHASE II, TOTAL METALS)

This section summarizes Quality Assurance of Phase II surficial marine sediment inorganics laboratory data according to Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988).

## 3.17.1 ANALYTICAL METHODS

Dried sediment samples were screened through a #10 ASTM testing sieve to remove the coarse grains greater than 2.00 mm diameter. The separated sample portions were weighed to determine the percent coarse fragments. Samples were analyzed for total metals according to EPA methods for flame atomic absorption spectraphotometry. Samples that registered  $\leq 2$  ug/ml arsenic by flame atomic absorption were re-analyzed for arsenic by hydride generation.

#### 3.17.2 SAMPLE HANDLING

The laboratory reported that samples T2S-5, T2-6, and T2-60 were warm when they arrived. Total metals results for these samples were flagged as estimates (J or N) due to inadequate sample preservation. Sample 88-4640 (T2-5) was mislabeled "T2-4" and sample T2-1 was mislabeled "T2-2" on the chain of custody forms.

#### 3.17.3 HOLDING TIMES

The sample holding times between collection and mercury analyses were 19 to 71 days, thus exceeding the 28-day holding time limit for many samples. Mercury results for those samples with holding times greater than 28 days were flagged as estimates (J or N). All other total metals analyses were completed well within the required sixmonth holding times.

#### 3.17.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal tested. A blank and at least four standards were used to establish analytical curves for mercury analyses.

Correlation Coefficients: EPA Functional Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. All standard curve correlation coefficients exceeded the 0.995 minimum.

Initial and Continuing Calibration Verifications: A review of the raw data verified that the calibration percent recoveries reported agreed with the values in the raw data. The initial calibration verification recovery of arsenic in the August 11 hydride generation analysis of WP287 (89 percent) was less than the 90 percent control limit.

No action was taken to qualify data because the ICV recovery was judged to be within rounding error of the control limit.

#### 3.17.5 BLANKS

Blank Frequency: The frequency of reagent blank testing exceeded the five percent frequency required by the project QA plan for all metals analyzed. No field blanks were collected due to the matrix of the samples.

<u>Blank Contamination</u>: All blank results were reported as less than the detection limits indicating laboratory contamination did not significantly influence sample results. A review of the raw data confirmed that blank results were accurately reported.

## 3.17.6 LABORATORY CONTROL SAMPLES

Nine laboratory control samples (reference samples) were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. At least one reference sample was tested at the beginning and again at the end of each sample analysis. All laboratory control sample results were within the certified ranges for those samples. A review of the raw data confirmed that these results were accurately reported.

#### 3.17.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: The five percent minimum duplicate analysis frequency was exceeded for all metals tested.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data verified these results.

#### 3.17.8 MATRIX SPIKE SAMPLE ANALYSIS

Spike Analysis Frequency: Four pre-digestion matrix spike samples and five spiked blanks were analyzed with each metal tested. Post-digestion matrix spike samples were analyzed for arsenic, copper and lead. These analyses exceeded the 5 percent quality control frequency specified in the project QA plan.

Spike Recovery: The concentration of total mercury in sample T14-2 exceeded the mercury concentration in the spiked sample resulting in a negative spike recovery. Mercury results for samples associated with this spike may be biased low. Total mercury results for the following samples were flagged as estimates (J): T4-4, T3-6, T3-5, T3-4, T2-5, T2A-5, T2-60, and T4-1 combined. Matrix spike recovery results were verified by recalculating the percentages from raw data.

# 3.17.9 FURNACE ATOMIC ABSORPTION QC

Furnace AA analyses were not performed on any Phase II surficial marine sediment samples.

# 3.17.10 SAMPLE RESULT VERIFICATION

Photocopies of all raw data forms were provided for the total metals and coarse fragment analyses. Results were also reported for standards that were used to plot standard quantitation curves. Copies of the instrumentation logs and standard operating procedures (SOPs) were also included with the laboratory data package.

The copper results for samples T4-1 combined and T4-2 combined and the lead result for T4-1 mixed were in error because they were quantitated using portions of the calibration curves that did not encompass the sample absorbances. The laboratory recalculated these results using curves with broader ranges of absorbances and sent corrected sample analysis reports.

The lead result reported for sample T3-20 was the average of an undiluted result and the result of an aliquot diluted by a factor of 10.

A review of the raw data and calculations turned up two data reduction errors that were corrected by the laboratory. The copper result for sample T3-2 (253 ppm) was corrected to 244 ppm and the mercury result for T16-4 (0.052 ppm) was corrected to 0.07 ppm.

# 3.17.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Two field duplicate samples were analyzed for total metals along with 46 samples, thus approaching the five percent duplicate frequency called for in the project QA plan.

Relative Percent Differences (RPDs): The RPDs between field duplicate samples T2-6 and T2-60 were all less than 20 percent or the difference between results were less than the CRQL. The RPDs between T3-2 and T3-20 were all less than 20 percent except the coarse fragment results (69 percent RPD). This high RPD was probably caused by the inclusion of one or two large, heavy particles in one sample that were not present in the duplicate.

# 3.18 SURFICIAL MARINE SEDIMENT INORGANICS (PHASE II, EP TOXICITY METALS)

This section summarized Quality Assurance of Phase II surficial marine sediment inorganics laboratory data according to Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988).

#### 3.18.1 ANALYTICAL METHODS

Surficial marine sediment EP Tox samples were prepared in accordance with Toxic Extraction Procedure protocols (EPA Method 1310) and analyzed according to EPA methods for flame atomic absorption spectraphotometry.

## 3.18.2 SAMPLE HANDLING

The laboratory reported that samples T2A-5, T2-6, and T2-60 were warm when they arrived. EP Tox metals results for these samples will be flagged as estimates (J or N) due to inadequate preservations. Same T2-1 was mislabeled "T2-2" and sample T2-5 was mislabeled "T2-4" on the chain on custody forms.

#### 3.18.3 HOLDING TIMES

The sample holding times between collection and mercury analyses were 21 to 53 days, thus exceeding the 28-day holding time for many samples. Mercury results for those samples with holding times greater than 28 days were flagged as estimates (Jorn N). All other EP Tox metals analyses were completed well within the required six-month holding times.

# 3.18.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal tested. A blank and at least four standards were used to establish analytical curves for mercury analyses.

<u>Correlation Coefficients</u>: EPA Functional Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. All standards curve correlation coefficients exceeded the 0.995 minimum.

<u>Initial and Continuing Calibration Verifications</u>: At least one Initial Calibration Verification (ICV) sample was analyzed at the beginning of each run and a Continuing Calibration Verification (CCV) sample was analyzed once every 10 samples. All ICV and CCV recoveries were within the ±10 percent control limits indicating the instrument calibrations remained valid throughout the analyses. A review of the raw data verified that calibration recoveries were accurately reported.

#### 3.18.5 BLANKS

Blank Frequency: The frequency of reagent blank testing exceeded the five percent frequency required by the project QA plan for all metals analyzed. No field blanks were collected due to the matrix of the samples.

Blank Contamination: All blank results were reported as less than the detection limits indicating laboratory contamination did not significantly influence sample results. A review of the raw data confirmed that blank results were accurately reported.

# 3.18.6 LABORATORY CONTROL SAMPLES

Eight laboratory control samples (reference samples) were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. At least one reference sample was tested at the beginning and again the end of each sample analysis. All laboratory control sample results were within the certified ranges for these samples. A review of the raw data confirmed that these results were accurately reported.

#### 3.18.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: The five percent minimum duplicate analysis frequency was exceeded for all metals tested.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data confirmed these results.

# 3.18.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spike Analysis Frequency</u>: Three matrix spike samples and three spike blanks were tested with each EP Tox metal analysis, thus exceeding the five percent spike frequency minimum.

<u>Spike Recovery</u>: All matrix spike recoveries were within the  $\pm$  25 percent quality control limits indicating matrix effects did not significantly influence sample results. Matrix spike recoveries were verified by recalculating them from the raw data.

# 3.18.9 FURNACE ATOMIC ABSORPTION QC

Furnace AA analyses were not performed on Phase II surficial marine sediment samples.

#### 3.18.10 SAMPLE RESULT VERIFICATION

Photocopies of all raw data forms were provided for EP Tox metals analyses. Results were also reported for standards that were used to plot standard quantitation curves.

Copies of the instrumentation logs and standard operating procedures (SOPs) were also included with the laboratory data package. The raw data was reviewed and no transcription or data reduction errors were detected.

# 3.18.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Two field duplicate samples were analyzed along with the 26 EP Tox samples, thus exceeding the five percent duplicate frequency required by the project QA plan.

Relative Percent Differences: EP Toxicity metals were not detected in any of the field duplicate samples so there were no differences in the results.

# 3.19 SURFICIAL MARINE SEDIMENT ORGANICS (PHASE I)

This section summarizes Quality Assurance of marine sediment organics data according to EPA Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses (USEPA 1988, USEPA 1985).

#### 3.19.1 ANALYTICAL METHODS

Moisture Content: moisture content was analyzed according to EPA Method 160.3 and reported in percent.

<u>Semi-volatiles</u>: compounds on the Hazardous Substance List (HSL) were extracted and analyzed by GC/MS according to protocols established in USEPA Contract Laboratory Program (CLP) (USEPA 1988). Semi-volatile results were reported in mg/kg on both a dry-weight basis and as-received basis.

#### 3.19.2 HOLDING TIMES

Holding time requirements have not been specifically set for a soil matrix. Therefore, the guidelines used for these data validations are those established for water matrices under 40 CFR 136 (Clean Water Act). 1) extraction within seven days. 2) analysis within 40 days. All analyses of semi-volatile organics were within control limits except for the following:

• MSO-3-3 had to be re-extracted due to the presence of 2 phases in the initial extract. This re-extraction was 20 days past the sample collection date which exceeded the 7 day sample holding time.

# 3.19.3 GC/MS TUNING

Mass Calibration: Standard decafluorotriphenylphosphine (DFTPP) mass calibrations were appropriately performed and reported on Form V.

<u>Ion Abundance</u>: Each mass calibration satisfied the ion abundance criteria. The data presented on each Form V compared with the corresponding mass listings. We found no transcription or calculation errors and the reported numbers contain the appropriate number of significant figures. These results demonstrated that instrument tuning and performance met EPA criteria to ensure mass resolution and compound identification.

<u>Calibration Frequency</u>: Performance of the mass calibrations occurred within 12 hours for most samples analyzed with the exception of the following:

• Samples MSO-16-1, MSO-16-2, and MSO-17-2 had to be reanalyzed with a dilution factor of ten. In the process of this re-analysis, the samples were run after the 12 hour limit. However, all instrument tuning ratios were well within control limits so no action was taken to qualify or reject the data.

#### 3.19.4 CALIBRATION

Instrument Calibration: Results of the initial calibration checks demonstrated that the GC/MS instrument was capable of producing acceptable quantitative data. Continuing calibration checks performed on each day of sample analysis documented satisfactory maintenance and adjustment of the instruments.

Average Relative Response Factors: Average relative response factors (RRF) were calculated for each semi-volatile compound on the target compound list (TCL) using five calibration points. All system performance check compounds (SPCC) had average RRFs greater than or equal to the 0.05 control limit in all initial and continuing calibrations. The percent differences between average RRFs reported for initial and continuing calibrations were less than the 25 percent maximum for all calibration check compounds (CCC).

These results were verified by re-calculating the response factors (RF) for one or more of the (CCC) five point calibrations. Calculations of the average RF, RRF were verified for each of the SPCC's and CCC's. No errors were detected.

Relative Standard Deviations: Relative standard deviations (RSD) of response factors were calculated for each semi-volatile compound on the TCL. All calibration check compound RSDs were less than or equal to the 30 percent control limit. Recalculation of the RSDs for the SPCC and CCC compounds in the initial calibrations detected no errors.

#### 3.19.5 **BLANKS**

<u>Laboratory Blanks</u>: Method blanks were analyzed for each set of extracted samples resulting in a frequency that exceeded the one-per-twenty-samples frequency called for in the project QA plan. No field blanks were analyzed because soil matrix blanks are not available.

Blank Contamination: Blank results were verified by inspecting chromatograms and quantitation reports. Analysis of blanks associated with the following samples showed contamination that required data qualification action.

- MSO-7-7: showed levels of diethylphthalate greater than in the blank but less than 5 times the blank concentration. Qualified as undetected (U).
- MSO-14-3, MSO-14-2, MSO-15-3, MSO-12-2, and MSO-12-3: showed approximately the same levels of Di-n-butylphthalate and Bis-2-ethylhexylphthalate as the blank. Data for these compounds is qualified as undetected.

Blank Quantitation Limits: The compound quantitation limits reported for method blank analyses were generally consistent with sample analyses and matched the Contract Required Quantitation Limits (CRQLs) listed in CLP.

#### 3.19.6 SURROGATE RECOVERY

BNA Surrogate Recovery: Laboratory performance on each semi-volatile organics sample was established by spiking the sample with six surrogate compounds. With only a few exceptions (listed below) the surrogate recoveries were generally within control limits established in the CLP.

- MSO-3-2: showed high recovery of Phenol-d5. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.
- MSO-7-1: had low recovery of Terphenyl-d14 however, the re-injection met the QA limits. No action is required.
- MSO-9-5 (field replicate): showed high surrogate recovery of 2,4,6-tribromophenol. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.
- MSO-10-2: showed low surrogate recovery of 2-fluorophenol. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.
- MSO-12-1: showed high recovery of Terphenyl-d14. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.
- MSO-13-1: showed high recovery of Terphenyl-d14. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.
- MSO-14-2: had a recovery of only 1 percent for Phenol-d5. There-injection met the QA limits. No action is required.
- MSO-16-3: showed low recovery of 2-fluorophenol. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.

Method Blank Surrogate Recovery: All semi-volatile surrogate recoveries were within control limits for method blank analyses.

<u>Calculations</u>: Surrogate recovery results were verified by comparison with quantitation reports and no transcription or calculation errors were detected.

# 3.19.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: MS/MSD results were verified by comparing them to quantitation reports and re-calculating percent recoveries and RPDs. No transcription or calculation errors were detected.

Matrix Spike Frequency: MS/MSD analyses were performed for each semi-volatile organics extraction batch, thus exceeding the one-matrix-spike-per-twenty-samples frequency specified in the project QA plan.

Spike Recoveries: matrix spike (MS) and matrix spike duplicate (MSD) recoveries were generally within established advisory limits indicating acceptable long-term accuracy of the analytical method. The following are instances where the QA limits were exceeded. However, these results alone are not intended to evaluate the precision and accuracy of individual samples. An exception was made to this rule in the case listed below under Memorandum M-7.

- Memorandum M-1: The percent recovery of 4-Chloro-3-methylphenol in the matrix spike sample and the percent recovery of pyrene in the spike and the duplicate samples exceeded the QA limits. No actions were taken to qualify or reject these sample results.
- Memorandum M-2: The surrogate recovery of 2,4,6-Tribromophenol in the matrix spike duplicate sample (LLI# 1208628) was 6% above the 122% QC upper limit. The QA/QC procedures allow one surrogate to exceed the limits before corrective action is required unless that recovery is below 10 percent which was not the case in this instance. No actions were taken to qualify of reject these sample results.
- Memorandum M-5: Matrix spiked duplicate recovery of pyrene was well above the QC limit. No actions were taken to qualify of reject these sample results.
- Memorandum M-7: The recovery of pyrene in the matrix spike and matrix spike duplicate samples was -347% and -18% respectively (i.e., essentially zero). Since trace amounts of pyrene (below the specified detection limits) were found in sample MSO-8-2 we deemed it appropriate to qualify these results as detection limit estimates (N).
- Memorandum M-10: Matrix spiked and matrix spiked duplicate recoveries exceeded QC limits for 4-nitrophenol. This compound was not detected in the samples and other MS/MSD results were within control limits, thus no action was taken to qualify or reject sample results.
- Memorandum M-11: The internal laboratory QA results (MS and MSD) showed that the spike recovery of Phenol-d5 exceeded the QC limits of 90 percent. No actions were taken to qualify of reject these sample results.
- Memorandum M-12: The percent recovery of Phenol and 2,4-Dinitrotoluene exceeded the spike recovery QA limits in the matrix spike and the matrix spike duplicate samples. No actions were taken to qualify of reject these sample results.
- Memorandum M-13: Matrix spiked recoveries of phenol, 4-chloro-3-methylphenol, and 2,4-dinitrotoluene exceeded QC limits. Matrix spiked duplicate recoveries exceeded control limits for 2-chlorophenol, phenol, 4-chloro-3-methylphenol, 4-

nitrophenol, and 2,4-dinitrotoluene. No actions were taken to qualify or reject sample results.

• Memorandum M-14: Matrix spiked recoveries exceeded QC limits for phenol, 4-chloro-3-methylphenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the samples and other MS/MSD results were within control limits, thus no action was taken to qualify or reject sample data.

Relative Percent Differences (RPDs): The relative percent differences between MS and MSD recoveries were generally within established advisory limits indicating acceptable long-term precision of the analytical method.

- Memorandum M-1: The RPD between the MS and MSD exceeded the QC limits for spike compound, 4-Chloro-3-methylphenol. In addition, the MSD sample showed concentrations 17 percent higher on average than the matrix spike sample but no additional compounds were observed. No qualification actions are deemed necessary.
- Memorandum M-5: The high recovery of pyrene in the MSD sample resulted in a high (RPD) from the MS sample for pyrene. Pyrene was not detected in the other samples of the case and other MS/MSD comparisons were within control limits, thus no action was taken to qualify data.
- Memorandum M-8: The RPD between the MS and MSD samples exceeded the control limits for 4-Chloro-3-methylphenol, 1,2,4-Trichlorobenzene, and Pyrene. No qualification actions were taken.
- Memorandum M-14: The relative percent difference (RPD) between the spiked and duplicate spiked results was twice the 33 percent QC limit for 4-chloro-3-methylphenol. This compound was not detected in the corresponding samples and other MS/MSD results were within control limits, thus no action was taken to qualify or reject data.

# 3.19.8 FIELD DUPLICATES/REPLICATES

<u>Duplicate Analyses</u>: Field duplicate samples were collected and analyzed for an indication of overall precision, including both field and laboratory precision. Sediment samples typically show greater variance than water samples due to difficulties associated with collecting identical samples.

Relative Percent Differences: The RPDs between field duplicate analyses of moisture content, and semi-volatile organics were within control limits (± 35%) indicating acceptable field and analytical precision.

<u>Duplicate Frequency</u>: Six field duplicate samples were collected for 125 total marine sediment samples, which is slightly less than the one-duplicate-per-twenty-samples frequency specified in the project QA plan.

## 3.19.9 INTERNAL STANDARDS PERFORMANCE

Internal Standard Areas: Internal standard area data was improperly retrieved by the computer program for one of the standards in a few instances. The laboratory sent corrected forms for these samples that demonstrated internal standard areas were within control limits. Internal standard areas and retention times were verified by comparing the Internal Standard Area Summary Forms (Form VIII) to quantitation reports and no transcription errors were detected.

Sample matrix interference resulted in standard areas that did not meet quality control criteria indicating that GC/MS sensitivity and response was not stable during every run. In many cases the sample was diluted, re-injected and re-analyzed resulting in acceptable internal standard areas. The acceptable range was: no more than 100% above or less than 50% below the 12 hour standard areas. When the re-analysis resulted in internal standards that were still out of limits, compounds associated with those internal standards were flagged as estimates (J or N).

The samples listed under the following standard area compounds did not meet QA limits, requiring qualifications to the data for associated compounds.

- 1,4-Dichlorobenzene-d5: MSO-4-0, MSO-7-7, MSO-9-3, and MSO-10-2.
- Naphthalene-d4: MSO-3-1, MSO-4-0, MSO-9-3, and MSO-10-2.
- Acenaphthene-d10: MSO-3-1.
- Phenanthrene-d10: MSO-2-3, MSO-3-2, and MSO-4-0.
- Chrysene-d12: MSO-10-2.

<u>Retention Times</u>: The retention times of internal standards did not vary more than 30 seconds from the associated 12 hour calibration standards.

#### 3.19.10 TARGET COMPOUND IDENTIFICATION

Relative Retention Times: Inspections of mass spectra confirmed that semi-volatile target compound relative retention times (RRTS) were within 0.06 RRT units of their corresponding standard RRTs.

Mass Spectra Criteria: Comparisons of the presence and relative intensity of ion peaks between sample and standard spectra verified semi-volatile target compound identifications.

# 3.19.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Compound Quantitation: Raw data was examined to verify the correct calculation of all sample results reported by the laboratory. Our review verified that the correct internal standards, quantitation ions, and response factors were used to quantitate each compound. Results were re-calculated and no calculation or transcription error were detected.

Detection Limits: Detection limits were correctly adjusted to reflect sample dilutions.

# 3.19.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory conducted a mass spectral search of the NBS library and reported the estimated quantities for the 15 largest semi-volatile peaks which were not surrogate, internal standard, or TCL compounds, but which had areas greater than 10 percent of the area of the nearest internal standard.

Positive results for biphenyl, dibenzothiophene, dimethylaniline, 1-methyl(2-methyl ethyl)benzene, and methylphenanthrenes were reported in the final results and flagged by the laboratory as estimates. Other tentatively identified compounds (TICs) were not listed as compounds of interest in the ASARCO RI Sampling and Analysis Plan and were not reported in the final results. All contractually required peaks were library searched and the tentative identifications were judged to be acceptable.

# 3.20 SURFICIAL MARINE SEDIMENT ORGANICS (PHASE II)

This section summarizes Quality Assurance of marine sediment organics data according to EPA Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses (USEPA 1988, USEPA 1985).

# 3.20.1 ANALYTICAL METHODS

Moisture Content: moisture content was analyzed according to EPA Method 160.3 and reported in percent.

<u>Semi-volatiles</u>: compounds on the Hazardous Substance List (HSL) were extracted and analyzed by GC/MS according to protocols established in USEPA Contract Laboratory Program (CLP) (USEPA 1988). Semi-volatile results were reported in mg/kg on both a dry-weight basis and as-received basis.

PCBs: were analyzed according to EPA Method 3540 and reported in mg/kg (EPA WW 846 2nd ed. 1984).

#### 3.20.2 HOLDING TIMES

Holding time requirements have not been specifically set for a soil matrix. Therefore, the guidelines used for these data validations are those established for water matrices under 40 CFR 136 (Clean Water Act). 1) extraction within seven days. 2) analysis within 40 days. All analyses of semi-volatile organics were within control limits except for the following:

- T22-1, T22-2, and T4-4 were re-extracted due to contamination in the method blank. This re-extraction occurred 22 days after the sampling date which exceeded the 7 day sample holding time.
- T3-5, T3-4, T2-5, and T3-6 had unspecified problems with the method blank which required re-extraction. This re-extraction took place 25 days after sampling which exceeded the 7 day holding time.
- T2A-5, T2A-50, and T2-6 were warm when they were received at ASARCO Technical Service Center. This violated the protocol for holding the samples.

# 3.20.3 GC/MS TUNING

Mass Calibration: Standard decafluorotriphenylphosphine (DFTPP) mass calibrations were appropriately performed and reported on Form V.

<u>Ion Abundance</u>: Each mass calibration satisfied the ion abundance criteria. The data presented on each Form V compared with the corresponding mass listings. We found no transcription or calculation errors and the reported numbers contain the appropriate number of significant figures. These results demonstrated that instrument

tuning and performance met EPA criteria to ensure mass resolution and compound identification.

<u>Calibration Frequency</u>: Performance of the mass calibrations occurred within 12 hours for most samples analyzed with the exception of the following:

• T3-2 and T11-7 were initially run more than 12 hours after a calibration and had to be re-injected because all of the instrument tuning ratios were not within control limits.

# 3.20.4 CALIBRATION

Instrument Calibration: Results of the initial calibration checks demonstrated that the GC/MS instrument was capable of producing acceptable quantitative data. Continuing calibration checks performed on each day of sample analysis documented satisfactory maintenance and adjustment of the instruments.

Average Relative Response Factors: Average relative response factors (RRF) were calculated for each semi-volatile compound on the target compound list (TCL) using five calibration points. All system performance check compounds (SPCC) had average RRFs greater than or equal to the 0.05 control limit in all initial and continuing calibrations. The percent differences between average RRFs reported for initial and continuing calibrations were less than the 25 percent maximum for all calibration check compounds (CCC).

These results were verified by re-calculating the response factors (RF) for one or more of the (CCC) five point calibrations. Calculations of the average RF, RRF were verified for each of the SPCC's and CCC's. No errors were detected.

Relative Standard Deviations: Relative standard deviations (RSD) of response factors were calculated for each semi-volatile compound on the TCL. All calibration check compound RSDs were less than or equal to the 30 percent control limit. Recalculation of the RSDs for the SPCC and CCC compounds in the initial calibrations detected no errors.

Calibration for PCB Analysis: The laboratory submitted calibration tables that list the response factors for each peak generated from the initial injection of four standards. Calibration response factors were calculated by dividing the amount of standard injected by the chromatogram peak height. Calibration linearity was checked by calculating the percent relative standard deviations (RSDs) of response factors for the four standards. RSDs ranged from 15 to nearly 60 percent. These results along with holding time limit violations contributed to the decision to flag PCB results as estimates.

#### 3.20.5 BLANKS

<u>Laboratory Blanks</u>: Method blanks were analyzed for each set of extracted samples resulting in a frequency that exceeded the one-per-twenty-samples frequency called for in the project QA plan. No field blanks were analyzed because soil matrix blanks are not available.

Blank Contamination: Blank results were verified by inspecting chromatograms and quantitation reports. Analysis of blanks associated with the following samples showed contamination that required data qualification action.

- T16-4: had to be re-injected because the Method Blank failed to meet Internal Standard Area OA limits.
- T22-1, T22-2, and T4-4: were re-extracted due to contamination in the blank for the first extraction.
- T2A-5, T2A-50, T2-6, T0-2, T0-3, T1-1, and T2-1: Di-n-butylphthalate was detected in the Method Blank associated with these samples. Since it was dot detected in any of the samples no qualifiers were needed in the data.

Blank Quantitation Limits: The compound quantitation limits reported for method blank analyses were generally consistent with sample analyses and matched the Contract Required Quantitation Limits (CRQLs) listed in CLP.

#### 3.20.6 SURROGATE RECOVERY

BNA Surrogate Recovery: Laboratory performance on each semi-volatile organics sample was established by spiking the sample with six surrogate compounds. With only a few exceptions (listed below) the surrogate recoveries were generally within control limits established in the CLP.

- T18-2: showed low recovery of 2,4,6-Tribromophenol was below the QA limits of 19% (12%). No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.
- T16-4 (Matrix Spike Dup.): showed low recovery of 2,4,6-Tribromophenol was below the QA limits of 19% (12%). No action is required since the Matrix Spike samples are only intended for long-term comparisons.

<u>PCB Surrogate Recovery</u>: Laboratory performance on each PCB sample was established by spiking the sample with the surrogate compound oxychlordane. Recovery of oxychlordane was within the control limit for each sample.

Method Blank Surrogate Recovery: All semi-volatile surrogate recoveries were within control limits for method blank analyses.

<u>Calculations</u>: Surrogate recovery results were verified by comparison with quantitation reports and no transcription or calculation errors were detected.

#### 3.20.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: MS/MSD results were verified by comparing them to quantitation reports and re-calculating percent recoveries and RPDs. No transcription or calculation errors were detected.

Matrix Spike Frequency: MS/MSD analyses were performed for each semi-volatile organics/PCB extraction batch, thus exceeding the one-matrix-spike-per-twenty-samples frequency specified in the project QA plan.

<u>Spike Recoveries</u>: matrix spike (MS) and matrix spike duplicate (MSD) recoveries were generally within established advisory limits indicating acceptable long-term accuracy of the analytical method. The following are instances where the QA limits were exceeded. However, these results alone are not intended to evaluate the precision and accuracy of individual samples. An exception was made to this rule in the case listed below under Memorandum M-7.

- Memorandum MS2-1: The percent recovery of 4-nitrophenol and pentachlorophenol were below the QA limits in the matrix spike duplicate analysis. No actions were taken to qualify or reject sample results.
- Memorandum MS2-4: The percent recovery of 2,4-Dinitrotoluene in the Matrix Spike sample was higher than the QC limits. The percent recovery of arochlor 1242 was below the control limits for the matrix spike sample. However, no actions were required to qualify or reject the results.
- Memorandum MS2-5: The percent recovery of 2,4-Dinitrotoluene in the Matrix Spike sample was higher than the QC limits. The percent recovery of arochlor 1242 was below the control limits for the matrix spike sample. However, no actions were required to qualify or reject the results.
- Memorandum MS2-8: The MS/MSD analysis of Total Organic Carbon (TOC)
  exceeded the QA limits. However, the MS/MSD results are not intended to
  evaluate the precision and accuracy of individual samples. Therefore no
  qualifications to the TOC data are required.

Relative Percent Differences (RPDs): The relative percent differences between MS and MSD recoveries were generally within established advisory limits indicating acceptable long-term precision of the analytical method.

• Memorandum MS2-1: The low recoveries of 4-nitrophenol and pentachlorophenol were below the QA limits in the matrix spike duplicate analysis. This resulted in the relative percent difference (RPD) between the matrix spike (MS) and matrix

spike duplicate (MSD) samples to exceed the QA limits for these compounds as well. No actions were taken to qualify or reject sample results.

- Memorandum MS2-2: The relative percent difference (RPD) of 1,4-Dichlorobenzene between the matrix spike (MS) and matrix spike duplicate (MSD) samples exceeded the QA limits. No action was taken to qualify or reject the sample results.
- Memorandum MS2-4: The RPD of pentachlorophenol between the MS and MSD samples were higher than the QC limits. However, no qualifications are required of the data based on MS/MSD results.
- Memorandum MS2-5: The RPD of pentachlorophenol between the MS and MSD samples were higher than the QC limits. However, no qualifications are required of the data based on MS/MSD results.

# 3.20.8 FIELD DUPLICATES/REPLICATES

<u>Duplicate Analyses</u>: Field duplicate samples were collected and analyzed for an indication of overall precision, including both field and laboratory precision. Sediment samples typically show greater variance than water samples due to difficulties associated with collecting identical samples.

Relative Percent Differences: The RPDs between field duplicate analyses of moisture content, PCB, and semi-volatile organics were within control limits (± 35%) indicating acceptable field and analytical precision.

<u>Duplicate Frequency</u>: Six field duplicate samples were collected for 125 total marine sediment samples, which is slightly less than the one-duplicate-per-twenty-samples frequency specified in the project QA plan.

# 3.20.9 INTERNAL STANDARDS PERFORMANCE

<u>Internal Standard Areas</u>: Internal standard area data was improperly retrieved by the computer program for one of the standards in a few instances. The laboratory sent corrected forms for these samples that demonstrated internal standard areas were within control limits. Internal standard areas and retention times were verified by comparing the Internal Standard Area Summary Forms (Form VIII) to quantitation reports and no transcription errors were detected.

Sample matrix interference resulted in standard areas that did not meet quality control criteria indicating that GC/MS sensitivity and response was not stable during every run. In many cases the sample was diluted, re-injected and re-analyzed resulting in acceptable internal standard areas. The acceptable range was: no more than 100% above or less than 50% below the 12 hour standard areas. When the re-analysis resulted in internal standards that were still out of limits, compounds associated with those internal standards were flagged as estimates (J or N).

Retention Times: The retention times of internal standards did not vary more than 30 seconds from the associated 12 hour calibration standards.

## 3.20.10 TARGET COMPOUND IDENTIFICATION

Relative Retention Times: Inspections of mass spectra confirmed that semi-volatile target compound relative retention times (RRTS) were within 0.06 RRT units of their corresponding standard RRTs.

Mass Spectra Criteria: Comparisons of the presence and relative intensity of ion peaks between sample and standard spectra verified semi-volatile target compound identifications.

# 3.20.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Compound Quantitation: Raw data was examined to verify the correct calculation of all sample results reported by the laboratory. Our review verified that the correct internal standards, quantitation ions, and response factors were used to quantitate each compound. Results were re-calculated and no calculation or transcription error were detected.

Detection Limits: Detection limits were correctly adjusted to reflect sample dilutions.

# 3.21 MARINE SEDIMENT CORE INORGANICS

This section summarizes Quality Assurance of marine sediment core metals laboratory data according to Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (USEPA 1988).

#### 3.21.1 ANALYTICAL METHODS

Sediment core samples were collected and analyzed for both total metals and EP Tox metals. Total metals samples were screened through a #10 ASTM testing sieve to remove the coarse grains greater than 2.00 mm diameter. The separated sample portions were weighed to determine the percent coarse fragments. Samples were analyzed for total metals according to EPA methods for flame atomic absorption spectraphotometry. EP Tox samples were prepared in accordance with Toxic Extraction Procedure protocols (EPA Method 1310) and analyzed according to EPA flame atomic absorption spectraphotometry methods. Both flame AA and colorimetric methods were employed in the arsenic analyses.

#### 3.21.2 SAMPLE HANDLING

All samples were handled properly as specified in the project QA plan.

# 3.21.3 HOLDING TIMES

The sample holding times between collection and mercury analyses were 45 to 72 days, thus exceeding the 28-day holding time maximum.

All mercury results were flagged as estimated (J or N). All other metals analyses were completed well within the required six-month holding times.

# 3.21.4 CALIBRATION

<u>Calibration Frequency</u>: A blank and at least three standards were used to establish analytical curves on each day of analysis for each metal tested. A blank and at least four standards were used to establish analytical curves for mercury analyses.

<u>Correlation Coefficients</u>: EPA Functional Guidelines (USEPA 1988) established a minimum correlation coefficient of 0.995 as a technical criterion to judge the acceptability of standard curves for use in the quantitation of metals. All standard curve correlation coefficients exceeded the 0.995 minimum.

Initial and Continuing Calibration Verifications: At least one initial calibration verification (ICV) sample was analyzed at the beginning of each run and a continuing calibration verification (CCV) sample was analyzed once every 10 samples. The ICV recovery for the EP Tox colorimetric analysis of arsenic (85 percent) was less than the 90 percent minimum control limit indicating associated arsenic results may be biased low. EP Tox arsenic results for the following samples were flagged as

estimates (J): 10A-01, T7-2-01, T7-2-12, T7-2-23, T7-2-34, T7-2-45, T13-2.5-01, T13-2.5-12, T13-2.5-23, and T12-2.5-34. The ICV recovery for EP Tox mercury (129 percent) exceeded the 120 percent upper control limit but no action was taken to qualify data because mercury was not detected in associated samples.

All other ICV and CCV recoveries were within the  $\pm 10$  percent control limits indicating the instrument calibrations remained valid throughout the analyses. A review of the raw data verified that calibration recoveries were accurately reported.

# **3.21.5** BLANKS

Blank Frequency: The frequency of reagent blank testing exceeded the five percent frequency required by the project QA plan for all metals analyzed. No field blanks were collected due to the matrix of the samples.

Blank Contamination: All blank results were reported as less than the detection limits indicating laboratory contamination did not significantly influence sample results. A review of the raw data confirmed that blank results were accurately reported.

#### 3.21.6 LABORATORY CONTROL SAMPLES

Eleven laboratory control samples (reference samples) were analyzed for various metals as a monitor of the overall performance of all steps in the analyses. At least one reference sample was tested at the beginning and again at the end of each sample analysis. All laboratory control sample results were within the certified ranges for these samples. A review of the raw data confirmed that these results were accurately reported.

#### 3.21.7 DUPLICATE SAMPLE ANALYSIS

<u>Duplicate Analysis Frequency</u>: Limited sample volumes did not allow the laboratory to analyze laboratory duplicate samples for the barium EP Tox analysis. The five percent minimum duplicate analysis frequency was exceeded in all other metal analyses.

Relative Percent Differences (RPDs): The RPDs between laboratory duplicates were all less than the 20 percent quality control limit. A review of the raw data confirmed these results.

#### 3.21.8 MATRIX SPIKE SAMPLE ANALYSIS

<u>Spike Analysis Frequency</u>: Two matrix spike samples were tested with each total metal and EP Tox metal analysis, thus meeting the five percent spike frequency minimum. Additionally, two spiked blanks were tested with most metal analyses.

<u>Spike Recovery</u>: All matrix spike recoveries were within the  $\pm 25$  percent quality control limits indicating matrix effects did not significantly influence sample results. Matrix spike recoveries were verified by recalculating them from the raw data.

# 3.21.9 FURNACE ATOMIC ABSORPTION QC

Furnace AA analyses were not performed on marine sediment core samples.

# 3.21.10 SAMPLE RESULT VERIFICATION

Photocopies of raw data forms were provided for all metals analyses. Results were also reported for standards that were used to plot standard quantitation curves. Copies of the instrumentation logs and standard operating procedures (SOPs) were also included with the laboratory data package.

A review of the raw data and calculations turned up two data reduction errors that were corrected by the laboratory. The total zinc result for sample T13-2.5-23 was corrected from 255 ppm to 270 ppm. The EP Tox zinc result for sample T7-2-34 was changed from 0.12 ppm to 1.18 ppm.

# 3.21.11 FIELD DUPLICATES/REPLICATES

<u>Duplicate Frequency</u>: Two field duplicate samples were analyzed for total metals and EP Tox metals along with 37 samples, thus meeting the five percent duplicate frequency called for in the project QA plan.

Relative Percent Differences: The relative percent differences (RPDs) between total metals results for field duplicate samples 10-23 and 10-230 were less than 30 percent for all metals except copper (50 percent). The RPDs between field duplicate total metals results for 2-12 and 2-120 were all less than 25 percent and the coarse fragment RPD was 56 percent. The variability evidenced by these results was judged to be acceptable considering the samples were collected from separate cores.

Most of the RPDs between EP Tox field duplicate results were less than 20 per; cent or the differences were less than twice the detection limits for EP Tox metals. The RPDs between field duplicate samples 10-23 and 10-230 were 127 percent for arsenic and 88 percent for zinc. The RPDs between field duplicates 2-12 and 2-120 were 50 percent for lead and 73 percent for zinc. When these same field duplicates were tested for total metals, the RPDs for arsenic, lead and zinc were all less than 30 percent. The high RPDs for EP Tox results indicated extractable metals concentrations were more variable than total metals and additional error may have been introduced by the extraction procedure. Field duplicate results were not used to qualify sample data.

# 3.22 MARINE SEDIMENT CORE ORGANICS

This section summarizes Quality Assurance of marine sediment coring organics data according to EPA Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses (USEPA 1988, USEPA 1985).

# 3.22.1 ANALYTICAL METHODS

Moisture Content: moisture content was analyzed according to EPA Method 160.3 and reported in percent.

<u>Semi-volatiles</u>: compounds on the Hazardous Substance List (HSL) were extracted and analyzed by GC/MS according to protocols established in USEPA Contract Laboratory Program (May 1984, revised July 1985) (CLP).

# 3.22.2 HOLDING TIMES

Holding time requirements used for these data validations are those established for water matrices under 40 CFR 136 (Clean Water Act). 1) extraction within seven days. 2) analysis within 40 days. The holding times to extraction for semi-volatile organics analysis exceeded the control limits for all coring samples. Therefore, all the positive results are flagged as estimates and all negative results as non-detected at the estimated detection limits

# 3.22.3 GC/MS TUNING

Mass Calibration: Standard decafluorotriphenylphosphine (DFTPP) mass calibrations were appropriately performed and reported on Form V.

<u>Ion Abundance</u>: Each mass calibration satisfied the ion abundance criteria. The data presented on each Form V compared with the corresponding mass listings. We found no transcription or calculation errors and the reported numbers contain the appropriate number of significant figures. These results demonstrated that instrument tuning and performance met EPA criteria to ensure mass resolution and compound identification.

<u>Calibration Frequency</u>: Performance of the mass calibrations occurred within 12 hours for all samples analyzed as required.

### 3.22.4 CALIBRATION

Instrument Calibration: Results of the initial calibration checks demonstrated that the GC/MS instrument was capable of producing acceptable quantitative data. Continuing calibration checks performed on each day of sample analysis documented satisfactory maintenance and adjustment of the instruments.

Average Relative Response Factors: Average relative response factors (RRF) were calculated for each semi-volatile compound on the target compound list (TCL) using five calibration points. All system performance check compounds (SPCC) had average RRFs greater than or equal to the 0.05 control limit in all initial and continuing calibrations. The percent differences between average RRFs reported for the continuing calibrations were less than 25% for all calibration check compounds (CCC).

These results were verified by re-calculating the response factors (RF) for one or more of the (CCC) five point calibrations. Calculations of the average RF, RRF were verified for each of the SPCC's and CCC's. No errors were detected.

Relative Standard Deviations: Relative standard deviations (RSD) of response factors were calculated for each semi-volatile compound on the TCL. All calibration check compound RSDs were less than or equal to the 30% control limit. Recalculation of the RSDs for the SPCC and CCC compounds in the initial calibrations detected no errors.

#### **3.22.5** BLANKS

<u>Laboratory Blanks</u>: One method blank was analyzed for each batch of samples. This met or exceeded the frequency of one-per-twenty-samples required by the project QA plan. No field blanks were analyzed because soil matrix blanks are not available.

Blank Contamination: Blank results were verified by inspecting chromatograms and quantitation reports. Trace amounts of di-n-butylphthalate was found in three of the lab blanks as well as in most of the associated samples, indicating a lab contamination problem. However, since the levels in the blanks and samples were similar and below the calibrated detection limits for the system no qualifications are required.

Blank Quantitation Limits: The compound quantitation limits reported for method blank analyses was consistent with sample analyses and matched the Contract Required Quantitation Limits (CRQLs) listed in CLP.

#### 3.22.6 SURROGATE RECOVERY

BNA Surrogate Recovery: Laboratory performance on each semi-volatile organics sample was established by spiking the sample with six surrogate compounds. The surrogate recoveries were generally within control limits established in the CLP with the following exceptions:

• 2,4,6-tribromophenol was above recovery limits in samples 10-01, 10-45, T-7-2-01, and T-16-0-1012. No action is required since only one surrogate is out of limits and the recovery was greater than 10 percent.

• 2-fluorobiphenyl and nitrobenzene were below recovery limits in sample 10A-12. Since two surrogates are out of limits the data for this sample are flagged as estimates or estimated detection limits.

Method Blank Surrogate Recovery: All semi-volatile surrogate recoveries were within control limits for method blank analyses.

<u>Calculations</u>: Surrogate recovery results were verified by comparison with quantitation reports and no transcription or calculation errors were detected.

#### 3.22.7 MATRIX SPIKES AND MATRIX SPIKE DUPLICATES

<u>Calculations</u>: MS/MSD results were verified by comparing them to quantitation reports and re-calculating percent recoveries and RPDs. No transcription or calculation errors were detected.

Matrix Spike Frequency: MS/MSD analyses were performed for each semi-volatile organics extraction batch, thus meeting the one-matrix-spike-per-twenty-samples frequency specified in the project QA plan.

Spike Recoveries: due to matrix interferences and dilution requirements, the matrix spike (MS) and matrix spike duplicate (MSD) recoveries did not meet established advisory limits for seven of eleven spike compounds in two of the sample batches. In one other batch, 2,4-dinitrotoluene exceeded the established limit (89%) by 1% in the matrix spike and 3% in the duplicate sample.

Since spike recovery results are intended to evaluate the long-term accuracy of the analytical method and not individual samples, no qualifications are recommended.

Relative Percent Differences (RPDs): The relative percent differences between MS and MSD recoveries were within established advisory limits for semi-volatiles indicating acceptable long-term precision of the analytical method.

# 3.22.8 FIELD DUPLICATES/REPLICATES

<u>Duplicate Analyses</u>: A field duplicate sample was collected and analyzed to provide an indication of overall precision, including both field and laboratory precision.

Relative Percent Differences: There are no specific control limits established for RPDs in field duplicate samples. However, the RPD of moisture content and semi-volatile organics were within the limits established for laboratory duplicates ( $\pm$  35%). Since field duplicates examine both field and laboratory variability, this sample is considered well within acceptable range.

<u>Duplicate Frequency</u>: Since almost half of the sampling sites could not be effectively sampled, only one of the four planned field duplicates was collected for the 36 core samples. Therefore, the one-duplicate-per-twenty-samples frequency specified in the project QA plan was not met.

#### 3.22.9 INTERNAL STANDARDS PERFORMANCE

Internal Standard Areas/Retention Times: Internal standard areas and retention times were verified by comparing the Internal Standard Area Summary Forms (Form VIII) to quantitation reports and no transcription errors were detected. The acceptable limits in standard area are no more than 100% above or less than 50% below the 12 hour standard areas. The retention times of internal standards are to be within 30 seconds of the associated 12 hour calibration standards. Internal standard areas and retention times were within control limits for all sample analyses.

#### 3.22.10 TARGET COMPOUND IDENTIFICATION

Relative Retention Times: Inspections of mass spectra confirmed that semi-volatile target compound relative retention times (RRTs) were within 0.06 RRT units of their corresponding standard RRT.

Mass Spectra Criteria: Comparisons of the presence and relative intensity of ion peaks between sample and standard spectra verified semi-volatile target compound identifications.

# 3.22.11 COMPOUND QUANTITATION AND DETECTION LIMITS

Compound Ouantitation: Raw data was examined to verify the correct calculation of all sample results reported by the laboratory. Our review verified that the correct internal standards, quantitation ions, and response factors were used to quantitate each compound. Results were re-calculated and no calculation or transcription error were detected.

Detection Limits: Detection limits were correctly adjusted to reflect sample dilutions.

# 4. CONCLUSIONS

Based on the data validation review, we found the analytical data to be generally acceptable as valid for the purposes of the ASARCO Tacoma Smelter Remedial Investigation and Feasibility Study. Only a few data points were rejected as unusable as a result of quality control violations. In some cases, the data required qualifiers to indicate estimated values and quantitation limits. These qualifiers do not limit the ability to form reliable interpretations of the entire data set.

# 5. APPENDICES

# 5.1 QA MEMORANDA

APPENDIX Q
SURFICIAL SOILS
QUALITY ASSURANCE MEMORANDA

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Project File March 22, 1988
Revised February 6, 1989

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

re: QA Review: ASARCO RI, Phase I Surficial Soil Laboratory Results; Total

Metals

to:

This QA review includes the following surficial soil samples analyzed by ASARCO for total metals:

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Dates
87-9540	SS-62	10-27-87	2-10-88 to 2-17-88
87-9541	SS-63A	10-27-87	2-10-88 to 2-17-88
87-9542	SS-63B	10-27-87	2-10-88 to 2-17-88
87-9543	SS-67	10-27-87	2-10-88 to 2-17-88
87-9544	SS-61	10-27-87	2-10-88 to 2-17-88
87-9545	SS-64	10-27-87	2-10-88 to 2-17-88
87-9546	SS-65	10-27-87	2-10-88 to 2-17-88
87-9547	SS-66	10-27-87	2-10-88 to 2-17-88
87-9548	SS-68	10-27-87	2-10-88 to 2-17-88
87-9549	SS-69	10-27-87	2-10-88 to 2-17-88
87-9550	SS-70	10-27 <b>-</b> 87	2-10-88 to 2-17-88
87-9587	SS-51	10-28-87	2-10-88 to 2-17-88
87-9588	SS-52	10-28-87	2-10-88 to 2-17-88
87-9589	SS-53	10-28-87	2-10-88 to 2-17-88
87-9590	SS-54	10-28-87	2-10-88 to 2-17-88
87-9591	SS-55	10-28-87	2-10-88 to 2-17-88
87-9592	SS-56	10-28-87	2-10-88 to 2-17-88
87-9593	SS-57	10-28-87	2-10-88 to 2-17-88
87-9594	SS-58A	10-28-87	2-10-88 to 2-17-88
87-9595	SS-58B	10-28-87	2-10-88 to 2-17-88
87-9596	SS-59	10-28-87	2-10-88 to 2-17-88
87-9597	SS-60	10-28-87	2-10-88 to 2-17-88
87-9630	MW4-S-1	09-30-87	2-10-88 to 2-17-88
87-9631	MW5-S-1	09-29-87	2-10-88 to 2-17-88

to: Project File from: James Good, Quality Assurance Officer March 22, 1988 Revised February 6, 1989 Page 2

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Dates
87-9633	MW7-S-1	10-05-87	2-10-88 to 2-17-88
87-9634	MW8-S-1	10-01-87	2-10-88 to 2-17-88
87-9636	MW10-S-1	09-25-87	2-10-88 to 2-17-88
87-9637	MW11-S-1	09-21-87	2-10-88 to 2-17-88
87-9638	MW12-S-1	09-24-87	2-10-88 to 2-17-88
87-9639	MW13-S-1	09-22-87	2-10-88 to 2-17-88
87-9833	SS-13	11-03-87	2-10-88 to 2-17-88
87-9834	SS-24	11-03-87	2-10-88 to 2-17-88
87-9835	SS-25	11-03-87	2-10-88 to 2-17-88
87-9836	SS-26	11-03-87	2-10-88 to 2-17-88
87-9912	SS-01	11-04-87	2-10-88 to 2-17-88
87-9913	SS-02	11-04-87	2-10-88 to 2-17-88
87-9914	SS-09A	11-04-87	2-10-88 to 2-17-88
87-9915	SS-09B	11-04-87	2-10-88 to 2-17-88
87-9916	SS-10	11-04-87	2-10-88 to 2-17-88
87-9917	SS-11	11-04-87	2-10-88-to 2-17-88
87-9918	SS-12	11-04-87	2-10-88 to 2-17-88
87-9964	SS-23	11-05-87	2-10-88 to 2-17-88
87-9965	SŞ-27	11-05-87	2-10-88 to 2-17-88
87-9966	SS-19	11-05-87	2-10-88 to 2-17-88
87-9967	SS-20	11-05-87	2-10-88 to 2-17-88
87-9968	SS-21	11-05-87	2-10-88 to 2-17-88
87-9969	SS-22	11-05-87	2-10-88 to 2-17-88
87-10046	SS-46	11-09-87	2-10-88 to 2-17-88
87-10047	SS-45	11-09-87	2-10-88 to 2-17-88
87-10048	SS-50	11-09-87	2-10-88 to 2-17-88
87-10049	SS-49	11-09-87	2-10-88 to 2-17-88
87-10050	SS-42	11-09-87	2-10-88 to 2-17-88
87-10051	SS-41	11-09-87	2-10-88 to 2-17-88
87-10052	SS-44	11-09-87	2-10-88 to 2-17-88
87-10053	SS-43	11-09-87	2-10-88 to 2-17-88
87-10054	SS-48	11-09-87	2-10-88 to 2-17-88
87-10055	SS-47	11-09-87	2-10-88 to 2-17-88
87-10056	SS-40	11-09-87	2-10-88 to 2-17-88
87-10057	SS-39	11-09-87	2-10-88 to 2-17-88

to: Project File

from: James Good, Quality Assurance Officer

March 22, 1988

Revised February 6, 1989

Page 3

- <u>ASARCO-I.D.</u>	Parametrix I.D.	Sample Date	Analysis Dates
87-10085	SS-28	11-10-87	2-10-88 to 2-17-88
87-10086	SS-29	11-10-87	2-10-88 to 2-17-88
87-10087	SS-30	11-10-87	2-10-88 to 2-17-88
87-10088	SS-31A	11-10-87	2-10-88 to 2-17-88
87-10089	SS-31B	11-10-87	2-10-88 to 2-17-88
87-10090	SS-32	11-10-87	2-10-88 to 2-17-88
87-10091	SS-33	11-10-87	2-10-88 to 2-17-88
87-10092	SS-34	11-10-87	2-10-88 to 2-17-88
87-10093	SS-35	11-10-87	2-10-88 to 2-17-88
87-10094	<b>SS-36</b>	11-10-87	2-10-88 to 2-17-88
87-10095	<b>SS-37</b>	11-10-87	2-10-88 to 2-17-88
87-10096	SS-38	11-10-87	2-10-88 to 2-17-88
87-10126	SS-6	11-11-87	2-10-88 to 2-17-88
87-10127	SS-8	11-11-87	2-10-88 to 2-17-88.
87-10128	SS-3	11-11-87	2-10-88 to 2-17-88.
87-10129	SS-4	11-11-87	2-10-88 to 2-17-88
87-10130	SS-16	11-11-87	2-10-88 to 2-17-88

These surficial soil samples were collected between October 27 and November 11, 1987 and analyzed for total metals between February 10 and February 17, 1988. The holding time requirement for mercury established for water matrix samples is 28 days. In the absence of statistically determined holding times for soil matrix samples, the water matrix holding times were applied to these surficial soil samples. All mercury results were flagged as estimates (J or N).

A sufficient number of duplicate samples, spiked samples, post digestion spiked samples, and reagent blanks were analyzed to comply with the QA/QC protocol agreement between ASARCO and USEPA.

Duplicate analyses were performed on samples SS-8, SS-10, SS-27, SS-33, SS-43, SS-48, SS-52, SS-58A, SS-59, and SS-62. All relative percent differences (RPDs) between duplicate analyses were within the  $\pm 20$  percent quality control limits.

Spike sample recoveries were reported for samples SS-3, SS-8, SS-27, SS-43, SS-63A and SS-70 and all were within the  $\pm 25$  percent control limits. The laboratory reported that the spike was unsuitable for the arsenic, lead, copper, silver, and zinc analyses of samples SS-27 and SS-43; and the arsenic and silver analyses of sample SS-8. Post-digestion spike analyses were performed on these samples and the spike recoveries were all within the

to: Project File from: James Good, Quality Assurance Officer March 22, 1988 Revised February 6, 1989 Page 4

±15 percent control limits. The laboratory also reported that the spike chosen was unsuitable for the range of sample values in the February 10 arsenic analysis. No action was taken to qualify sample data based on spike recoveries.

Initial calibration verification results were within the acceptable range for each standard. Two of the continuing calibration verification (CCV) samples analyzed on February 11 had recoveries for antimony (114.5 percent) that exceeded the 110 percent control limit. Antimony results for soil samples associated with these CCVs (SS-3, SS-6, SS-28, SS-36, SS-37, SS-40, SS-47 and SS-48) may be biased high and will be flagged as estimates (J).

The correlation coefficients calculated to assess the acceptability of standard curves were less than the 0.995 minimum for cadmium (0.993) and lead (0.994). All surficial soils results for these metals were flagged as estimates (J or N).

Nine reference samples were analyzed for various metals and all results were within the certificate range given for each analysis.

Metals were not detected in any reagent blanks.

The RPDs for field duplicates were generally less than 25 percent indicating high overall precision in sampling and analyses. The RPD for antimony in samples SS-31A and SS-31B was 36 percent. No action was taken to qualify sample data based on field duplicate results.

Other laboratory QA parameters tested were within limits established in the QA/QC protocol agreement.

JG:kjr

Project File November 2, 1988
Revised January 31, 1989

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

re: QA Review: ASARCO RI, Surficial Soil Laboratory Results; Phase I EP

Toxicity Metals

to:

This QA review includes the following samples analyzed by ASARCO for Extraction Procedure Toxicity metals:

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Dates
87-9558	SS-62	10-27-87	12-29-87 to 2-3-88
87-9559	SS-63A	10-27-87	12-29-87 to 2-3-88
87-9560	SS-63B	10-27-87	12-29-87 to 2-3-88
87-9561	SS-67	10-27-87	12-29-87 to 2-3-88
87-9562	SS-61	10-27-87	12-29-87 to 2-3-88
87-9563	SS-64	10-27-87	12-29-87 to 2-3-88
87-9564	SS-65	10-27-87	12-29-87 to 2-3-88
87-9565	SS-66	10-27-87	12-29-87 to 2-3-88
87-9566	SS-68	10-27-87	12-29-87 to 2-3-88
87-9567	SS-69	10-27-87	12-29-87 to 2-3-88
87-9568	SS-70	10-27-87	12-29-87 to 2-3-88
87-9606	SS-51	10-28-87	12-29-87 to 2-3-88
87-9607	SS-52	10-28-87	12-29-87 to 2-3-88
87-9608	SS-53	10-28-87	12-29-87 to 2-3-88
87-9609	SS-54	10-28-87	12-29-87 to 2-3-88
87-9610	. SS-55	10-28-87	12-29-87 to 2-3-88
87-9611	SS-56	10-28-87	12-29-87 to 2-3-88
87-9612	SS-57	10-28-87	12-29-87 to 2-3-88
87-9613	SS-58A	10-28-87	12-29-87 to 2-3-88
87-9614	SS-58B	10-28-87	12-29-87 to 2-3-88
87-9615	SS-59	10-28-87	12-29-87 to 2-3-88
87-9616	SS-60	10-28-87	12-29-87 to 2-3-88
87-9837	SS-13	11-03-87	12-29-87 to 2-3-88
87-9838	SS-24	11-03-87	12-29-87 to 2-3-88
87-9839	SS-25	11-03-87	12-29-87 to 2-3-88
87-9840	SS-26	11-03-87	12-29-87 to 2-3-88

to: Project File from: James Good, Quality Assurance Officer November 2, 1988
Revised January 31, 1989
Page 2

07.0010	66.04	11 01 07	10.00.07 . 0.0.00
87-9919	SS-01	11-04-87	12-29-87 to 2-3-88
87-9920	SS-02	11-04-87	12-29-87 to 2-3-88
87-9921	SS-09A	11-04-87	12-29-87 to 2-3-88
87-9922	SS-09B	11-04-87	12-29-87 to 2-3-88
87-9923	<u>SS-10</u>	11-04-87	12-29-87 to 2-3-88
87-9924	SS-11	11-04-87	12-29-87 to 2-3-88
87-9925	SS-12	11-04-87	12-29-87 to 2-3-88
87-9970	SS-23	11-05-87	12-29-87 to 2-3-88
87-9971	SS-27	11-05-87	12-29-87 to 2-3-88
87-9972	SS-19	11-05-87	12-29-87 to 2-3-88
87-9973	SS-20	11-05-87	12-29-87 to 2-3-88
87-9974	SS-21	11-05-87	12-29-87 to 2-3-88
87-9975	SS-22	11-05-87	12-29-87 to 2-3-88
87-10058	SS-46	11-09-87	12-29-87 to 2-3-88
87-10059	SS-45	11-09-87	12-29-87 to 2-3-88
87-10060	SS-50	11-09-87	12-29-87 to 2-3-88
87-10061	SS-49	11-09-87	12-29-87 to 2-3-88
87-10062	SS-42	11-09-87	12-29-87 to 2-3-88
87-10063	SS-41	11-09-87	12-29-87 to 2-3-88
87-10064	SS-44	11-09-87	12-29-87 to 2-3-88
87-10065	SS-43	11-09-87	12-29-87 to 2-3-88
87-10066	SS-48	11-09-87	12-29-87 to 2-3-88
87-10067	SS-47	11-09-87	12-29-87 to 2-3-88
87-10068	SS-40	11-09-87	12-29-87 to 2-3-88
87-10069	SS-39	11-09-87	12-29-87 to 2-3-88
87-10097	SS-28	11-10-87	12-29-87 to 2-3-88
87-10098	SS-29	11-10-87	12-29-87 to 2-3-88
87-10099	SS-30	11-10-87	12-29-87 to 2-3-88
87-10100	SS-31A	11-10-87	12-29-87 to 2-3-88
87-10101	SS-31B	11-10-87	12-29-87 to 2-3-88
87-10102	SS-32	11-10-87	12-29-87 to 2-3-88
87-10102	SS-33	11-10-87	12-29-87 to 2-3-88
87-10103	SS-34	11-10-87	12-29-87 to 2-3-88
87-10104	SS-35	11-10-87	12-29-87 to 2-3-88
87-10103			12-29-87 to 2-3-88
87-10100	SS-36	11-10-87	12-29-87 to 2-3-88
	SS-37	11-10-87	
87-10108 87-10131	SS-38	11-10-87	12-29-87 to 2-3-88
	SS-6	11-11-87	12-29-87 to 2-3-88
87-10132 87-10133	SS-8	11-11-87	12-29-87 to 2-3-88
87-10133	SS-3	11-11-87	12-29-87 to 2-3-88
87-10134	SS-4	11-11-87	12-29-87 to 2-3-88

to:

Project File

from:

James Good, Quality Assurance Officer

November 2, 1988

Revised January 31, 1989

Page 3

87-10135 SS-16 11-11-87

12-29-87 to 2-3-88

These surficial soil samples were collected between October 27 and November 11, 1987, and analyzed for EP Tox metals between December 29, 1987 and February 3, 1988. The 28-day holding time requirement for mercury was exceeded by three weeks to more than one month, thus all mercury results were flagged as estimates (J or N).

Only two standards and a blank were used to generate a standard curve for the quantitation of silver, but silver was not detected in any samples and no action was taken to qualify data. All other standard curves were generated with a blank and three or more standards.

The correlation coefficient of the standard curve for cadmium (0.983) did not meet the 0.995 technical criterion established for judging the acceptability of standard curves, thus the following cadmium results were flagged as estimates (J or N):

SS-62	<b>SS-68</b>	SS-55	SS-13	SS-30
SS-63A	SS-69	SS-56	SS-24	SS-32
SS-63B	SS-70	SS-57	SS-25	SS-35
SS-67	SS-51	SS-58A	SS-26	SS-37
SS-61	SS-52	SS-58B	SS-41	SS-6
SS-64	SS-53	SS-59	SS-48	SS-3
SS-65	SS-54	SS-60	SS-47	

All initial (ICV) and continuing (CCV) calibration recoveries were within the certified ranges for each calibration standard.

No metals were detected in the EP Tox analysis of reagent blanks.

Only three laboratory duplicate samples and three matrix spiked samples were analyzed for each metal resulting in frequencies of one per 23 samples. Although these frequencies did not meet the one-per-20-samples frequencies specified in the QA Plan, they were regarded as minor departures from protocol and no action was taken to qualify data. Laboratory duplicate RPDs were all less than the 20 percent maximum quality control limit. All spike recoveries were within the  $\pm 25$  percent limits.

The RPDs for arsenic (90 percent) and barium (120 percent) were high for field duplicates SS-63A and SS-63B, but were less than 25 percent for the other three duplicate pairs. Field duplicate RPDs were relatively high for SS-63A and SS-63B (57 percent), SS-09A and SS-09B (89 percent), and SS-31A and SS-31B (30 percent).

to:

Project File

from:

James Good, Quality Assurance Officer

November 2, 1988

Revised January 31, 1989

Page 4

The RPDs for lead in SS-63A and SS-63B (96 percent), and SS-09A and SS-09B (32 percent) also were high. High field duplicate RPDs indicated low overall precision, but no quality control limits were applied to these data.

Other laboratory QA parameters tested were within limits established in the QA/QC protocol agreement.

JG:kjr

to: Project File March 6, 1989

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

re: QA Review: ASARCO RI, Surficial Soils Laboratory Results, Phase II;

Total Metals and Percent Coarse Fragments

This QA review includes the following samples analyzed by ASARCO for total metals and percent coarse fragments:

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
88-8064	SS2-01 Cooling Pond	10-20-88	12-09-88
88-806 <i>5</i>	SS2-02 Cooling Pond	10-20-88	12-09-88
88-8066	SS2-03 Cooling Pond	10-20-88	12-09-88
88-8067	SS2-04 Cooling Pond	10-20-88	12-09-88
88-8068	SS2-05 Cooling Pond	10-20-88	12-09-88
88-8069	SS2-06 Large Lot	10-21-88	12-09-88
88-8070	SS2-07 Large Lot	10-21-88	12-09-88
88-8071	SS2-08 Large Lot	10-21-88	12-09-88
88-8072	SS2-09 Large Lot	10-21-88	12-09-88
88-8073	SS2-10 Large Lot	10-21-88	12-09-88
88-8074	SS2-11 Large Lot	10-21-88	12-09-88
88-8075	SS2-12 Large Lot	10-21-88	12-09-88
88-8076	SS2-13 Large Lot	10-21-88	12-09-88
88-8077	SS2-14 Large Lot	10-21-88	12-09-88
88-8078	SS2-15 Large Lot	10-21-88	12-09-88
88-8079	SS2-16 Large Lot	10-21-88	12-09-88
88-8080	SS2-17 Large Lot	10-21-88	12-09-88
88-8081	SS2-18 Medium Lot	10-21-88	12-09-88
88-8082	SS2-19 Medium Lot	10-21-88	12-09-88
88-8083	SS2-20 Medium Lot	10-21-88	12-09-88
88-8084	SS2-21 Medium Lot	10-21-88	12-09-88
88-8085	SS2-22 Medium Lot	10-21-88	12-09-88
88-8086	SS2-23 Medium Lot	10-21-88	12-09-88
88-8087	SS2-24 Small Lot	10-20-88	12-09-88
88-8088	SS2-25 Small Lot	10-20-88	12-09-88

to:

Project File

from:

James Good, Quality Assurance Officer

March 6, 1989

Page 2

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
88-8089	SS2-26 Cooling Pond (Field Duplicate)	10-20-88	12-09-88
88-8090	SS2-27 Large Lot (Field Duplicate)	10-20-88	12-09-88

These surficial soil samples were collected on October 20 and 21, 1988, and received by the laboratory on November 4. The 49 or 50 days between sample collection and mercury analyses exceeded the 28-day holding time for mercury. All mercury results will be flagged as estimates (J).

The percent recoveries of chromium in the laboratory control sample NBS-2704 (Buffalo River Sediment) (76 percent) were less than the 80 percent quality control limit. The laboratory noted that the "soft digestion" procedure was not amenable to total extraction of chromium from this matrix. Recoveries of chromium in the laboratory control sample NBS-1645 (River Sediment) were within control limits as were matrix spike recoveries for chromium, thus no action was taken to qualify sample data.

No pre-digestion matrix spiked samples were analyzed for lead, arsenic, and copper because the sample results were greater than four times the spike amount.

Matrix spike recovery of antimony was 45 percent for sample SS2-01 and 28.5 percent for SS2-21. These results indicate that all antimony data may be biased low. All positive antimony results will be flagged as estimates (J) and negative antimony results will be flagged as estimated detection limits.

The mercury results for sample SS2-17 was incorrectly reported as 6.8 ppm. The laboratory is sending a correction sheet with the correct result of 13.6 ppm. The laboratory is also sending a correction sheet to change the antimony result for sample SS2-09 from 13 ppm to <13 ppm.

The relative percent differences (RPDs) between field duplicate samples SS2-03 and SS2-26 were 99 percent for copper, 121 percent for mercury, 45.3 percent for zinc, and exceeded the CRQL for antimony. The RPD between field duplicate samples SS2-15 and SS2-27 was 63.6 percent for antimony. These results indicate low overall precision that may reflect the variability of these metals in surficial soils at the sites sampled.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

to: Project File March 6, 1989

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

re: QA Review: ASARCO RI, Phase II Surficial Soils EP Tox Metals

This QA review includes the following surficial soils samples analyzed by ASARCO for metals by the Extraction Procedures Toxicity method:

ASARCO I.D.	Parametrix I.D.	Sampling Date	Analysis Date
88-8037	SS2-01 Cooling Pond	10-20-88	12-08-88
88-8038	SS2-02 Cooling Pond	10-20-88	12-08-88
88-8039	SS2-03 Cooling Pond	10-20-88	12-12-88
88-8040	SS2-04 Cooling Pond	10-20-88	12-08-88
88-8041	SS2-05 Cooling Pond	10-20-88	12-12-88
88-8042	SS2-06 Large Lot	10-21-88	12-08-88
88-8043	SS2-07 Large Lot	10-21-88	12-08-88
88-8044	SS2-08 Large Lot	10-21-88	12-08-88
88-8045	SS2-09 Large Lot	10-21-88	12-08-88
88-8046	SS2-10 Large Lot	10-21-88	12-12-88
88-8047	SS2-11 Large Lot	10-21-88	12-08-88
88-8048	SS2-12 Large Lot	10-21-88	12-08-88
88-8049	SS2-13 Large Lot	10-21-88	12-08-88
88-8050	SS2-14 Large Lot	10-21-88	12-12-88
88-8051	SS2-15 Large Lot	10-21-88	12-08-88
88-8052	SS2-16 Large Lot	10-21-88	12-08-88
88-8053	SS2-17 Large Lot	10-21-88	12-08-88
88-8054	SS2-18 Medium Lot	10-21-88	12-08-88
88-8055	SS2-19 Medium Lot	10-21-88	12-08-88
88-8056	SS2-20 Medium Lot	10-21-88	12-12-88
88-8057	SS2-21 Medium Lot	10-21-88	12-08-88
88-8058	SS2-22 Medium Lot	10-21-88	12-12-88
88-8059	SS2-23 Medium Lot	10-21-88	12-08-88
88-8060	SS2-24 Small Lot	10-20-88	12-08-88
88-8061	SS2-25 Small Lot	10-20-88	12-08-88
88-8062	SS2-26 Duplicate	10-20-88	12-08-88
88-8063	SS2-27 Duplicate	10-21-88	12-08-88

to:

Project File

from:

James Good, Quality Assurance Officer

March 6, 1989

Page 2

These surficial soils samples were collected on October 20 and 21, 1988, and received by the laboratory on November 4, 1988. The 46 to 47 day holding time from sample collection to analysis exceeded the 28-day holding time maximum for mercury. All positive mercury results will be flagged as estimates (J) and all negative mercury results will be flagged as detection limit estimates (N).

The initial calibration verification (ICV) percent recoveries for both selenium analyses (113.5 percent) exceeded the 110 percent quality control limit, and the first continuing calibration verification (CCV) sample recovery (87.5) was less than the 90 percent minimum. Positive selenium results for samples SS2-01 and SS2-22 will be flagged as estimates (J) and negative selenium results for SS2-02 and SS2-15 will be flagged as detection limit estimates (N).

Two field duplicate samples were analyzed to provide indications of overall precision. The relative percent differences (RPDs) between field duplicate results were less than 25 percent except copper results for samples SS2-03 and SS2-26 (92 percent). The high RPD for copper may indicate a high degree of variability of extractable copper in the surficial soils at this site.

Other QA parameters tested were within the quality control limits established in the project QA plan.

JG:kjr

to: Project File March 6, 1989

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

re: QA Review: ASARCO RI, Phase II Surficial Soils, Arsenic Depth Study

This QA review includes the following samples analyzed for total arsenic by ASARCO:

ASARCO I.D.	Parametrix I.D.	Sampling Date	Analysis Date
88-8091	SS2-05A Cooling Pond	10-20-88	11-30-88
88-8092	SS2-05B Cooling Pond	10-20-88	11-30-88
88-8093	SS2-05C Cooling Pond	10-20-88	11-30-88
88-8094	SS2-06A Large Lot	10-21-88	11-30-88
88-8095	SS2-07B Large Lot	10-21-88	11-30-88
88-8096	SS2-07C Large Lot	10-21-88	11-30-88
88-8097	SS2-12A Large Lot	10-21-88	11-30-88
88-8098	SS2-12B Large Lot	10-21-88	11-30-88
88-8099	SS2-12C Large Lot	10-21-88	11-30-88
88-8100	SS2-14A Large Lot	10-21-88	11-30-88
88-8101	SS2-14B Large Lot	10-21-88	11-30-88
88-8102	SS2-14C Large Lot	10-21-88	11-30-88
88-8103	SS2-18A Medium Lot	10-21-88	11-30-88
88-8104	SS2-18B Medium Lot	10-21-88	11-30-88
88-8105	SS2-18C Medium Lot	10-21-88	11-30-88
88-8106	SS2-21A Medium Lot	10-21-88	11-30-88
88-8107	SS2-21B Medium Lot	10-21-88	11-30-88
88-8108	SS2-21C Medium Lot	10-21-88	11-30-88
88-8109	SS2-24A Small Lot	10-20-88	11-30-88
88-8110	SS2-24B Small Lot	10-20-88	11-30-88
88-8111	SS2-24C Small Lot	10-20-88	11-30-88

These soil samples were collected on October 20 and 21, 1988, and received by the laboratory on November 4, 1988. All samples were analyzed well within the six-month holding time limit.

to:

Project File

from:

James Good, Quality Assurance Officer

March 6, 1989

Page 2

The matrix spike recovery of arsenic for sample 88-8091 (127.5 percent) exceeded the 125 percent quality control limit. All positive arsenic results will be flagged as estimates (J).

Other QA parameters tested were within limits established in the project QA plan.

JG:kjr

to: Project File September 27, 1988

from: James Good, Quality Assurance Officer Revised November 11, 1988 55-1643-03 (0241A)

re: MEMORANDUM S1 QA Review: ASARCO R1, Surficial Soil Laboratory

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

Results; Phase I Organic Compounds

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1207986	SS-69	10-27-87	11-04-87	11-16-87
1207987	SS-70	10-27-87	11-04-87	11-16-87
1207995	SS-62	10-27-87	11-04-87	11-06-87
1207996	SS-63A	10-27-87	11-04-87	11-06-87
1207997	SS-63B (Duplicate)	10-27-87	11-04-87	11-07-87
1207998	SS-67	10-27-87	11-04-87	11-07-87
1207999	SS-61	10-27-87	11-04-87	11-07-87
1208000	SS-64	10-27-87	11-04-87	11-07-87
1208001	SS-65	10-27-87	11-04-87	11-07-87
1208002	SS-66	10-27-87	11-04-87	11-07-87
1208003	SS-68 (Unspiked Soil)	10-27-87	11-04-87	11-07-87
1208004	Matrix Spike	••	11-04-87	11-07-87
1208005	Matrix Spike Duplicate		11-04-87	11-07-87
1208007	Method Blank		11-04-87	11-07-87

These surficial soil samples were collected on October 27, 1987 and extracted for PCB analysis on November 4, 1987. The eight-day holding time to extraction exceeded the seven-day holding time requirement for PCB extraction. The percent relative standard deviation (% RSD) of sample peak response factors was nearly 50 percent for some PCB chromatogram peaks indicating poor linearity of calibration factors. PCBs were not detected in any samples, and negative results will be flagged as detection limit estimates (N).

The semi-volatile matrix spiked recoveries of 4-chloro-3-methylphenol (136 percent) and pyrene (191 percent) exceeded control limits of 103 and 142 percent, respectively. The duplicate matrix spiked recovery of pyrene (214 percent) also exceeded the 142 percent limit. And the relative percent difference (RPD) between MS and MSD results for 4-

to: Project File from: James Good, Quality Assurance Officer September 27, 1988 Revised November 11, 1988 Page 2

chloro-3-methylphenol (51 percent) exceeded the 33 percent limit. These compounds were not detected in samples and other MS/MSD results were within control limits, thus no action was taken to qualify data.

### LL1 #1207986 (SS-69)

The semi-volatile internal standard areas for chrysene-d12 and perylene-d12 were less than the lower control limits. The laboratory reported that the matrix of the sample affected internal standard integration as evidenced by the total ion current profile. Results for pyrene, butylbenzyl phthalate, 3,3-dichlorobenzidine, benzo(a)anthracene, bis (2-ethylhexyl)phthalate, chrysene, di-n-octyl phthalate, benzo(b)fluoranthene, benzo (k) fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene will be flagged as estimates (J or N).

The pesticide surrogate recovery of oxychlordane (58 percent) was less than the lower control limit. The semi-volatile surrogate recovery of terphenyl-d14 (151 percent) exceeded the upper control limit. Recoveries of the other five semi-volatile surrogate compounds were within control limits, thus no action was taken to qualify data.

Other QA parameters tested were within control limits established in the QA plan.

# LL1 #1207987 (SS-70)

The 10.1 percent sample moisture content reported by the laboratory was the average of a re-run analysis and a duplicate moisture analysis. The RPD between these two moisture content results was nine percent.

The semi-volatile surrogate recoveries of 2-flurobiphenyl, nitrobenzene-d5, and phenold6 were below control limits in the initial, undiluted sample analysis. The sample was diluted by a factor of ten and re-analyzed and these results were reported by the laboratory as the final sample data. The laboratory reported that the usual detection limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis. Surrogate recoveries for the dilution factor ten (DF10) run were not reported on the surrogate recovery QC form, but the recoveries for 2-flurophenol, phenol-d6, nitrobenzene-d5, 2-flurobiphenyl, and 2,4,6-tribromophenol were all below control limits on the quantitation report and the surrogate recovery of 2,4,6-tribromophenol was less than ten percent. These results indicate that there may have been semi-volatile compounds present in the sample that were not detected in the analysis. All sample results were below detection limits and they will be flagged as rejected (R).

to: Project File

from: James Good, Quality Assurance Officer

September 27, 1988

Revised November 11, 1988

Page 3

Semi-volatile internal standard areas of chrysene-d12 and perylene-d12 were below control limits in the initial, undiluted sample analysis. The laboratory reported that the matrix of the sample affected internal standard integration as evidenced by the total ion current profile or the dilution run of the sample. All DF10 internal standard areas were within control limits.

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1207995 (SS-62)

Semi-volatile internal standard areas were below the lower control limits for chrysened12 and perylene-d12 due to a significant matrix effect. Results for pyrene, butylbenzyl phthalate, 3,3-dichlorobenzidine, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, chrysene, di-n-octyl phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno (1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene will be flagged as estimates (J or N).

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1207996 (SS-63A)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

The semi-volatile internal standard area for perylene-d12 was below the lower control limit. Results for di-n-octyl phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo (a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene will be flagged as estimates (J or N).

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1207997 (SS-63B) Duplicate

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

to: Project File from: James Good, Quality Assurance Officer September 27, 1988 Revised November 11, 1988 Page 4

Other QA parameters tested were within control limits established in the project QA plan.

#### FIELD DUPLICATE ANALYSIS

The relative percent difference (RPD) between the moisture contents of samples SS-66 and SS-67 was less than one percent. The RPD between fluoranthene results was 11 percent and the RPD between pyrene results was seven percent. All other RPDs were zero percent. These results demonstrated high overall precision.

### LLI #1207998 (SS-67)

The internal standard area of perylene-d12 was below the lower control limits due to a significant matrix effect. Results for di-n-octyl phthalate, benzo(b)fluoranthene, benzo (k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene will be flagged as estimates (J or N).

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1207999 (SS-61)

The semi-volatile surrogate recovery of terphenyl-d14 (14 percent) was less than the lower control limit (18 percent). Recoveries of the other five semi-volatile surrogate compounds were within control limits, thus no action was taken to qualify data.

Semi-volatile internal standard areas were below the lower control limits for chrysene-d12 and perylene-d12. Results for pyrene, butylbenzyl phthalate, 3,3'-dichlorobenzidine, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, chrysene, di-n-octyl phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene will be flagged as estimates (J or N).

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1208000 (SS-64)

The semi-volatile internal standard areas were less than lower control limits for chrysened12 and perylene-d12 in the initial, undiluted sample analysis. The sample was diluted by a factor of ten and the re-analysis of the diluted sample resulted in all internal standard areas within control limits. The laboratory reported that the usual detection to: Project File

from: James Good, Quality Assurance Officer

September 27, 1988

Revised November 11, 1988

Page 5

limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis.

Other QA parameters tested were within control limits established in the project QA plan.

#### LLI #1208001 (SS-65)

All laboratory QA parameters tested were within QA limits established in the project QA plan.

### LLI #1208002 (SS-66)

All laboratory QA parameters tested were within QA limits established in the project QA plan.

# LLI #1208003 (SS-68) Unspiked Soil

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1208007 (Method Blank)

No target compounds were detected in the method blank. A tentatively identified phthalane ester was estimated at 1.0 mg/kg at a detection probability of 70 percent.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

JG:kjr

Project File October 4, 1988

Revised November 11, 1988

from: James Good, Quality Assurance Officer 55-1643-03 (0241A)

re: MEMORANDUM S2 QA Review: ASARCO RI, Surficial Soil Laboratory

Results, Organic Compounds

to:

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1208616	SS-51	10-28-87	11-11-87	11-14-87
1208617	SS-52	10-28-87	11-11-87	11-13-87
1208618	SS-53	10-28-87	11-11-87	11-13-87
1208619	SS-54	10-28-87	11-11-87	11-14-87
1208620	SS-55	10-28-87	11-11-87	11-14-87
1208621	SS-56	10-28-87	11-11-87	11-14-87
1208622	SS-57	10-28-87	11-11-87	11-14-87
1208623	SS-58A	10-28-87	11-11-87	11-14-87
1208624	SS-58B (Duplicate)	10-28-87	11-11-87	11-14-87
1208625	SS-59 ` Î	10-28-87	11-11-87	11-14-87
1208626	SS-60	10-28-87	11-11-87	11-14-87
	(Unspiked soil)			· .•
1208627	Matrix Spike		11-11-87	11-14-87
1208628	Matrix Spike		11-11-87	11-14-87
	Duplicate			
1208638	Method Blank		11-11-87	11-14-87

These surficial soil samples were collected on October 28, 1987 and received by the laboratory on October 30, 1987. The 14 days between sample collection and extraction for PCB analysis exceeded the seven-day holding time limit for this group of samples. All PCB and pesticide results will be flagged as estimates (J or N). The percent relative standard deviation (% RSD) of sample peak response factors were less than 27 percent.

The surrogate recovery of 2,4,6-tribromophenol (128 percent) exceeded the 127 percent control limit in the matrix spike duplicate sample. Surrogate recoveries of the other five compounds were within control limits, thus no action was taken to qualify data.

to: Project File

from: James Good, Quality Assurance Officer

October 4, 1988

Revised November 11, 1988

Page 2

The laboratory reported that the matrix spike and matrix spike duplicate results are not applicable to sample results due to the dilutions of the spiked samples because of a matrix affect. The spiked samples were diluted by a factor of twenty.

### LLI #1208616 (SS-51)

Sample matrix interference led the laboratory to re-analyze the sample after diluting it by a factor of 20. DF20 results were reported, thus the detection limits were 20 times higher than the contract required detection limits (CRDLs).

Semi-volatile internal standard areas that were below control limits for chrysene-d12 and perylene-d12 in the straight run were within limits in the DF20 analysis.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

### LLI #1208617 (SS-52)

DF20 results were reported, thus the detection limits were 20 times higher than the CRDLs. Semi-volatile internal standard areas that were reported as zero for the straight run were all within control limits in the DF20 analysis.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1208618 (SS-53)

DF20 results were reported, thus the detection limits were 20 times higher than the CRDLs.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1208619 (SS-54)

The moisture content reported by the laboratory was the average moisture content of two aliquots of sample SS-54. The RPD between moisture content results was one percent.

to: Project File from: James Good, Quality Assurance Officer October 4, 1988 Revised November 11, 1988 Page 3

The percent surrogate recovery of 2,4,6-tribromophenol (124) exceeded the 122 percent control limit and the internal standard area for chrysene-d12 was less than the lower control limit in the undiluted analysis of sample SS-54. The laboratory diluted the sample by a factor of 20 and DF20 data was reported in the final results. Detection limits reflect the dilution and are 20 times the CRDL.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

#### LLI #1208620 (SS-55)

The 15.7 percent moisture reported by the laboratory is the average of the original analysis and a duplicate analysis. The RPD between moisture content analyses was ten percent.

This sample was analyzed at DF20 and DF10, but results were reported for the undiluted analysis. The 12-hour frequency control limit for MS/MSD analysis was exceeded by 39 minutes for sample SS-55. No action was taken to qualify results.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

### LLI #1208621 (SS-56)

Sample SS-56 was run straight, analyzed at DF10, and re-analyzed at the undiluted concentration. Results from the second DF1 analysis were reported by the laboratory as the final results. The surrogate recovery of oxychlordane (41 percent) was less than the 80 percent QC limit. PCBs were not detected in sample SS-56 and the result was flagged as a detection limit estimate (N).

Other laboratory QA parameters tested were within control limits established in the project QA plan.

#### LLI #1208622 (SS-57)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

to: Project File

from: James Good, Quality Assurance Officer

October 4, 1988

Revised November 11, 1988

Page 4

The fluoranthene result for this sample was incorrectly reported. The laboratory sent a corrected analytical report with fluoranthene as received (0.8 mg/kg) and fluoranthene dry-weight (1.1 mg/kg).

DF20 was analyzed first, followed by a run of undiluted sample. Data from the undiluted analyses were reported by the laboratory as the final results. The internal standard area for perylene-d12 (17549) was less than the lower QC limit (19987) in the undiluted analysis. Results for compounds quantitated using the perylene-d12 standard (di-n-octyl phthalate; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; indeno(1,2,3-cd)pyrene; dibenz(a,h)anthracene; and benzo(g,h,i)perylene) were flagged as estimates (J or N).

Other laboratory QA parameters tested were within control limits established in the project QA plan.

### LLI #1208623 (SS-58A)

The laboratory reported that the usual detection limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis.

A DF20 analysis was performed by the laboratory, but all final results reported were from the DF10 analysis.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1208624 (SS-58B) Duplicate

The laboratory reported that the usual detection limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis. A DF20 analysis was performed by the laboratory, but all final results reported were from the DF10 analysis.

# Field Duplicate Analysis

No target semi-volatile organic compounds, PCBs or organochlorine pesticides were detected in samples SS-58A or SS-58B, thus the RPDs for the duplicate analysis of these compounds were zero.

to: Project File from: James Good, Quality Assurance Officer October 4, 1988 Revised November 11, 1988 Page 5

### LLI #1208625 (SS-59)

The laboratory reported that the usual detection limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis.

A DF20 analysis was performed by the laboratory, but all final results reported were from the DF5 analysis. Semi-volatile surrogate recovery of 2,4,6-tribromophenol (323 percent) exceeded the 122 percent control limit in the DF5 analysis. Percent recoveries of the other five semi-volatile organic compounds were within control limits, thus no action was taken to qualify data.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1208626 (SS-60) Unspiked Soil

The laboratory reported that the usual detection limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis.

DF20 data were reported in the final results for sample SS-60.

Other laboratory QA parameters tested were within limits established in the project QA plan.

#### LLI #1208638 Method Blank

All laboratory QA parameters tested were within limits established in the project QA plan. No target organic compounds or pesticides were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination of samples.

JG:kjr

to: Project File May 2, 1988

Revised November 11, 1988

from: James Good, Quality Assurance Officer 55-1643-03 (0241A)

re: MEMORANDUM S3 QA Review: ASARCO RI, Surficial Soil Laboratory Results;

Phase I Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1210620 1210589 1210590 1210591 1210592 1210593 1210594	SS-12 SS-1 SS-2 SS-9A SS-9B (Duplicate) SS-10 SS-11 Unspiked Soil	11-04-87 11-03-87 11-04-87 11-04-87 11-04-87 11-04-87	11-13-87 11-13-87 11-13-87 11-13-87 11-13-87 11-13-87	12-01-87 12-01-87 12-01-87 12-01-87 12-01-87 12-01-87 12-01-87
1210595 1210596 1210597	Matrix Spike Matrix Spike Duplicate Method Blank		11-13-87 11-13-87 11-13-87	12-01-87 12-01-87 11-30-87

These surficial soil samples were collected on November 4, 1987 and received by the laboratory on November 6, 1987. Extractions for PCBs were performed on November 13, 1987. The nine-day holding time from sample collection to extraction exceeded the seven-day holding time established for water samples. Due to limited information concerning holding times for soil samples, the water holding time criterion was applied to soil samples. The percent relative standard deviation (% RSD) of sample peak response factors was less than 27 percent. Positive results for PCBs will be flagged as estimated (J) and negative results will be flagged as detection limit estimates (N).

#### LLI #1210620 (SS-12)

The moisture content reported by the laboratory is the average moisture content of two aliquots of smaple SS-12. The RPD between moisture analyses was one percent.

Matrix spiked duplicate recovery of pyrene exceeded the QC limit. This high recovery resulted in a high relative percent difference (RPD) between the matrix spiked and

from: James Good, Quality Assurance Officer May 2, 1988 Revised November 11, 1988 Page 2

matrix spiked duplicate results for pyrene. The pyrene result for sample SS-12 will be flagged as an estimate (J). Other MS/MSD results were within control limits.

All other laboratory QA parameters tested were within established limits.

### LLI #1210589 (SS-01)

Dilution factor 10 (DF10) results were reported for phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene. Results reported for all other compounds tested were dilution factor one (DF1) values.

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. The pyrene result detected in this sample will be flagged as estimated (J).

All other laboratory QA parameters tested were within established limits.

# LLI #1210590 (SS-02)

DF 20 results were reported for naphthalene, acenaphthene, dibenzofuran, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i) perylene, and indono(1,2,3-c,d)pyrene. The DF1 result was reported for dibenz(a,h)anthracene.

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. The pyrene result detected in this sample will be flagged as estimated (J).

All other laboratory QA parameters tested were within established limits.

# LLI #1210591 (SS-9A) 1210592 (SS-9B) Duplicate

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

from: James Good, Quality Assurance Officer May 2, 1988 Revised November 11, 1988 Page 3

Internal standard areas were high for sample 1210592. However, the analyst determined that with the increased sensitivity he could detect any target compounds present in the sample.

### Field Duplicate Analysis

The relative percent difference (RPD) between the moisture content of sample SS-9A and that of SS-9B was one percent. No semi-volatile target compounds or PCBs were detected in either sample so the RPDs for these compounds are zero. These results indicate a high level of precision associated with field sampling.

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1210593 (SS-10)

DF 10 results were reported for phenanthrene, flouranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene. DF1 results were reported for all other compounds tested.

Sample data for perylene-d12 was improperly retrieved by the computer program causing the internal standard area for this semivolatile compound to be reported as zero. The corrected CLP Form 8 sent by the laboratory reported an internal standard area for perylene-d12 that was within QC limits.

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. The pyrene result detected in this sample will be flagged as estimated (J).

All other laboratory QA parameters tested were within established limits.

### LLI #1210594 (SS-11)

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Internal laboratory QA results indicated that organic analyses met other QA criteria.

from: James Good, Quality Assurance Officer May 2, 1988 Revised November 11, 1988 Page 4

### LLI #1210597 (Method Blank)

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

All other laboratory QA parameters tested were within established limits and no organic compounds were detected in the method blank.

to: Project File September 30, 1988

Revised November 11, 1988

from: James Good, Quality Assurance Officer 55-1643-03 (0241A)

re: MEMORANDUM S4 QA Review: ASARCO RI, Surficial Soil Laboratory

Results, Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1210541	SS-13	11-03-87	11-13-87	11-25-87
1210542	SS-24	11-03-87	11-13-87	11-25-87
1210543	SS-25	11-03-87	11-13-87	11-26-87
1210544	SS-26	11-03-87	11-13-87	11-26-87
313	Unspiked Soil		11-13-87	11-25-87
313	Matrix Spike		11-13-87	11-25-87
313	Matrix Spike	••	11-13-87	11-25-87
	Duplicate			
313	Method Blank		11-13-87	11-25-87

These soils samples were collected on November 3, 1987 and received by the laboratory on November 5, 1987. The 10 days between sample collection and extraction for PCB analysis exceeded the seven-day holding time limit for this group of samples. All PCB results will be flagged as detection limit estimates (N).

The percent relative standard deviation (% RSD) of sample peak response factors in the PCB sample analyses were less than 15 percent.

#### LLI #1210541 (SS-13)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

The laboratory computer system failed to properly pull the internal standard areas for chrysene and perylene from the calibration standard file. The laboratory sent a corrected Form 8 with manually generated standard areas.

to: Project File

from: James Good, Quality Assurance Officer

March 6, 1989

Page 2

All laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1210542 (SS-24)

All laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #1210543 (SS-25)

All laboratory QA parameters tested were within control limits established in the project QA plan.

### LLI #1210544 (SS-26)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

All laboratory QA parameters tested were within control limits established in the project QA plan.

# LLI #313 Method Blank

All laboratory QA parameters tested were within control limits established in the project QA plan. No target organic compounds or PCBs were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination to samples.

JG:kjr

### MEMORANDUM...

to: Project File Septer

September 30, 1988 Revised November 11, 1988

from: James Good, Quality Assurance Officer 55-1643-03 (0241A)

re: MEMORANDUM S5 QA Review: ASARCO RI, Surficial Soil Laboratory

Results, Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1211103	SS-23	11-05-87	11-13-87	11-20-87
1211104	SS-27	11-05-87	11-13-87	11-20-87
1211105	SS-19	11-05-87	11-13-87	11-20-87
1211106	SS-20	11-05-87	11-13-87	11-20-87
1211107	SS-21	11-05-87	11-13-87	11-23-87
1211108	SS-22	11-05-87	11-13-87	12-03-87
314A	Unspiked Soil	***	11-13-87	11-17-87
314A	Matrix Spike	*-	11-13-87	11-17-87
314A	Matrix Spike		11-13-87	11-17-87
	Duplicate			
314A	Method Blank	•• .	11-13-87	11-17-87

The 10 days between sample collection and extraction for PCB analysis exceeded the seven-day holding time control limit for this group of samples. The laboratory also reported the PCB surrogate recovery of oxychlordane (52 percent) was less than the lower control limit in the method blank analysis. The percent relative standard deviation (% RSD) of sample peak response factors were less than 28 percent. All PCB results will be flagged as estimates (J or N).

Semi-volatile organics extractions were performed on December 10, thus meeting the seven-day holding time requirements.

to: Project File

from: James Good, Quality Assurance Officer

September 30, 1988

Revised November 11, 1988

Page 2

### LLI #1211103 (SS-23)

The laboratory reported higher than usual detection limits due to sample matrix interference that required the sample to be diluted by a factor of fire.

Duplicate moisture content analyses had identical results (9.5 percent).

All laboratory QA parameters tested were within control limits established in the project QA plan.

## LLI #1211104 (SS-27)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

The moisture content result reported by the laboratory is the average moisture content of two aliquots of sample SS-27. The RPD between these duplicate moisture content results was four percent.

The laboratory reported higher than usual detection limits due to sample matrix interference that required the sample to be diluted by a factor of five.

All laboratory QA parameters tested were within control limits established in the project QA plan.

### LLI #1211105 (SS-19)

The original dilution factor five run of sample SS-19 resulted in low recoveries of all semi-volatile surrogate compounds. The sample was re-run straight and the semi-volatile surrogate recovery of terphenyl-d14 (159 percent) exceeded the upper control limit (137 percent). Percent recoveries of the other five surrogate compounds were within control limits for the re-run and no action was taken to qualify results.

The semi-volatile internal standard area for perylene-d12 (15372) was less than the lower control limit (17977) in the re-run analysis reported. Results for di-n-octyl phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene will be flagged as estimates (J or N).

Other laboratory QA parameters tested were within control limits established in the project QA plan.

to: Project File from: James Good, Quality Assurance Officer September 30, 1988 Revised November 11, 1988 Page 3

### LLI #1211106 (SS-20)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result for benzo(b)fluoranthene is the total for both isomers.

The laboratory reported higher than usual detection limits due to sample matrix interference that required the sample to be diluted by a factor of fire.

The semi-volatile surrogate recovery of terphenyl-d14 (150 percent) exceeded the upper control limit (137 percent). The other surrogate recoveries were within limits, thus no action was taken to qualify results.

Semi-volatile internal standard areas were less than lower control limits for chrysene-d12 and perylene-d12. The laboratory reported that the matrix of the sample affected internal standard integration as evidenced by the total ion current profile or the dilution run of the sample. Results for the following compounds associated with these internal standards will be flagged as estimates: pyrene, butylbenzyl phthalate, 3,3-dichlorobenzidine, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, chrysene, di-n-octyl phthalate, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h) anthracene, and benzo(g,h,i)perylene.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

### LLI #1211107 (\$S-21)

The laboratory reported that the usual detection limits could not be attained due to the matrix of the sample or interferences observed in the GC/MS analysis. Low surrogate recoveries were observed in the extraction and subsequent re-extraction of sample SS-21 indicating a significant matrix effect. Dilution factor five (DF5) and DF20 runs were analyzed prior to the DF50 analysis that was reported in the final results.

The semi-volatile surrogate recovery of nitrobenzene-d5 was reported as zero in the DF50 analysis. Negative results will be flagged as unusable (R) and positive results will be flagged as estimates (J).

Other laboratory QA parameters tested were within control limits established in the project QA plan.

to: Project File from: James Good, Quality Assurance Officer September 30, 1988 Revised November 11, 1988 Page 4

### LLI #1211108 (SS-22)

The laboratory reported that benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under sample analysis conditions. The result for benzo(b)fluoranthene is the total for both isomers.

The laboratory reported higher than usual detection limits due to sample matrix interference that required the sample to be diluted by a factor of five. The laboratory stated that the sample matrix affected internal standard integration as evidenced by the total ion current profile or the dilution run of the sample. Sample SS-22 was diluted by a factor of five, re-injected and re-analyzed after the initial run resulted in internal standard areas for chrysene-d12 and perylene-d12 that were below control limits. Internal standard areas were all within control limits for the DF5 analysis.

The semi-volatile surrogate recovery of terphenyl-d14 (172 percent) exceeded the 137 percent upper control limit in the initial analysis, but all surrogate recoveries were within limits in the DF5 analysis. No action was taken to qualify results.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

#### LLI #314A Method Blank

All laboratory QA parameters tested were within control limits established in the project QA plan. No target organic compounds or PCBs were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination to samples.

JG:kjr

to: Project File May 4, 1988
Revised November 11, 1988

from: James Good, Quality Assurance Officer 55-1643-03 (0241A)

re: MEMORANDUM S6 QA Review: ASARCO RI, Surficial Soil Laboratory Results; Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1212025	SS-44	11-09-87	11-17-87	11-24-87
1212026	SS-43	11-09-87	11-17-87	11-24-87
1212027	SS-48	11-09-87	11-17-87	11-24-87
1212028	SS-47	11-09-87	11-17-87	11-24-87
1212029	SS-40	11-09-87	11-17-87	11-24-87
1212030	SS-39	11-09-87	11-17-87	11-24-87
1212032	SS-46	11-09-87	11-17-87	11-24-87
1212033	SS-45	11-09-87	11-17-87	11-24-87
1212034	SS-50	11-09-87	11-17-87	11-24-87
1212035	SS-49	11-09-87	11-17-87	11-18-87
1212036	SS-42	11-09-87	11-17-87	11-25-87
1212037	SS-41 Unspiked Soil	11-09-87	11-17-87	11-23-87
1212038	Matrix Spike		11-17-87	11-23-87
1212039	Matrix Spike Duplicate	••	11-17-87	11-23-87
1212040	Method Blank Sample		11-17-87	11-23-87

These surficial soil samples were collected on November 9, 1987 and received by the laboratory on November 11, 1987. The eight-day holding time from sample collection to extraction for PCBs exceeded the seven-day holding time established for water samples. Due to limited information concerning holding times for soil samples, the water holding time criterion was applied to soil samples. The percent relative standard deviation (% RSD) of sample peak response factors were less than 17 percent. Positive

Page 2

results for PCBs will be flagged as estimated (J) and negative results will be flagged as detection limit estimates (N).

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)flouranthene were not resolved under the sample analysis conditions. The results reported for benzo(b)fluoranthene are the total for both isomers.

Matrix spike recovery (-347 percent) and duplicate matrix spike recovery (-18 percent) were below control limits for pyrene. All other MS/MSD results were within QC limits. Positive pyrene results for these samples will be flagged as estimates (J) and negative pyrene results will be flagged as unusable (R).

### LLI #1212025 (SS-44)

Dilution factor five (DF5) results were reported for phenanthrene, fluoranthene, and pyrene. Dilution factor one (DF1) results were reported for all other compounds tested.

Internal laboratory QA results indicated that other laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1212026 (SS-43)

The moisture content reported by the laboratory is the average result from the analysis of two aliquots of the sample. The RPD between duplicate moisture analysis results was 13 percent.

Other laboratory QA parameters tested were within limits established in the project QA plan.

### LLI #1212027 (SS-48)

The moisture content reported by the laboratory is the average result from the analysis of two aliquots of the sample. The RPD between duplicate moisture analysis results was two percent.

Other laboratory QA parameters tested were within limits established in the project QA plan.

### LLI #1212028 (SS-47)

The laboratory reported that the computer did not properly retrieve the internal standard area QC limits for perylene-d12. A corrected CLP Form 8 semi-volatile internal standard area summary sent by the laboratory shows the internal standard area for perylene-d12 was within the OC limits.

Other laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1212029 (SS-40)

DF10 results were reported for phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene. The laboratory reported DF1 results for all other compounds tested.

Semi-volatile internal standard area results from the DF1 analysis indicated the internal standard areas for chrysene-d12 and perylene-d12 were less than the lower QC limits. Internal standard areas reported for the DF10 analysis of these compounds are within QC limits indicating there was a sample matrix problem.

Other laboratory QA parameters tested were within limits established in the project QA plan.

### LLI #1212030 (SS-39)

PCB surrogate recovery of oxychlordane was less than the lower QC limit. The negative result reported for PCBs will be flagged as a detection limit estimate (N).

Other laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1212032 (SS-46)

All laboratory QA parameters tested were within limits established in the project QA plan.

## LLI #1212033 (SS-45)

DF10 results were reported for phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene. The laboratory reported DF1 results for all other compounds tested.

Semi-volatile internal standard area results from the DF1 analysis indicate the internal standard areas for chrysene-d12 and perylene-d12 were less than the lower QC limits. Internal standard areas reported for the DF10 analysis of these compounds are within QC limits indicating there was a sample matrix problem.

Other laboratory QA parameters tested were within limits established in the project QA plan.

## LLI #1212034 (SS-50)

All laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1212035 (SS-49)

Internal laboratory QA results indicated that laboratory QA parameters tested were within limits established in the project QA plan.

## LLI #1212036 (SS-42)

DF10 results were reported for phenanthrene, fluoranthene, pyrene, benzo(a) anthracene, chrysene, and benzo(b)fluoranthene. The laboratory reported DF1 results for all other compounds tested.

Semi-volatile internal standard area results from the DF1 analysis indicate the internal standard area for perylene-d12 was less than the lower QC limit. Internal standard area reported for the DF10 analysis of perylene-d12 was within QC limits indicating there was a sample matrix problem.

PCB surrogate recovery of oxychlordane was less than the lower QC limit.

Other laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1212037 SS-41 (Unspiked Soil Sample)

DF10 results were reported for phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, and benzo(b)fluoranthene. The laboratory reported DF1 results for all other compounds tested.

Other laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1212040 (Method Blank Sample)

Other laboratory QA parameters tested were within limits established in the project QA plan. No target organic compounds or PCBs were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination of samples.

JG:kjr

to: Project File

May 3, 1988

Revised November 11, 1988

from:

James Good, Quality Assurance Officer

55-1643-03 (0241A)

re:

MEMORANDUM S7 QA Review: ASARCO RI, Surficial Soil Laboratory

Results; Phase I Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1212221	SS-28	11-10-87	11-17-87	11-18-87
1212222	SS-29	11-10-87	11-17-87	11-18-87
1212223	SS-30	11-10-87	11-17-87	11-18-87
1212224	SS-31A	11-10-87	11-17-87	11-18-87
1212225	SS-31B (Duplicate)	11-10-87	11-17-87	11-19-87
1212226	SS-32	11-10-87	11-17-87	11-19-87
1212227	SS-33	11-10-87	11-17-87	11-19-87
1212228	SS-34	11-10-87	11-17-87	11-19-87
1212229	SS-35	11-10-87	11-30-87	12-01-87
1212230	SS-36	11-10-87	11-17-87	11-19-87
1212231	SS-37	11-10-87	11-17-87	11-19-87
1212232	SS-38	11-10-87	11-30-87	12-02-87
317-A	Unspiked Soil		11-17-87	11-17-87
317-A	Matrix Spike	••	11-17-87	11-17-87
317-A	Matrix Spike Duplicate	-	11-17-87	11-17-87
317-A	Method Blank	••	11-17-87	11-17-87

Samples SS-35 and SS-38 were collected on November 10, 1987 and received by the laboratory on November 12, 1987. Extractions for PCBs were performed on November 30, 1987. The twenty-day holding time from sample collection to extraction exceeded the seven-day holding time established for water samples. Due to limited information concerning holding times for soil samples, the water holding time criterion was applied to soils. The percent relative standard deviation (% RSD) for sample peak response factors were less than 25 percent. Positive results for PCBs will be flagged as estimated (J) and negative results will be flagged as detection limit estimates (N) in samples SS-35 and SS-38.

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total concentration of both isomers.

## LLI #1212221 (SS-28)

Duplicate moisture analyses resulted in a RPD of 53 percent. A second duplicate sample was analyzed resulting in a RPD of 17 percent. The average moisture content from the initial analysis and the second duplicate were reported in the final results.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

### LLI #1212222 (SS-29)

The moisture content result reported by the laboratory is the average moisture content of two aliquots of sample #1212222. The RPD between results of duplicate moisture analyses was 14 percent.

Dilution factor five (DF5) results were reported for phenanthrene, fluoranthene, and pyrene. Dilution factor one (DF1) results were reported for all other organic compounds tested.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

# LLI #1212223 (SS-30)

Dilution factor 5 results were reported for phenanthrene, fluoranthene, pyrene, and benzo(b)fluoranthene. DF1 results were reported for all other organic compounds tested.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

# LLI #1212224 (SS-31A) #1212225 (SS-31B) Duplicate

The laboratory reported DF5 results for phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene for sample SS-31A. DF5 results for these compounds as well as indeno(1,2,3-cd)pyrene and benzo(g,h,i) perylene were reported for the duplicate sample. DF1 results were reported for all other organic compounds tested.

The internal standard area reported for perylene-d12 was below the lower control limit at DF1. The internal standard area for this compound was within control limits when DF5 analysis was performed indicating a sample matrix problem.

## Field Duplicate Analysis

The relative percent differences calculated for the separate analysis of these duplicate samples exceeded 35 percent for naphthalene, 2-methylnaphthalene, acenapthylene, acenaphthene, dibenzofuran, fluorene, phenanthrene, anthracene, and 2,6-dinitrotoluene. These high RPDs may indicate low precision in sample collection or analysis procedures, or may simply reflect the variability of semi-volatile organic compounds in the soils at this sampling site.

Other laboratory QA parameters tested were within limits established in the project QA plan.

## LLI #1212226 (SS-32)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for 1,4-dichlorobenzene-d4. The laboratory sent a corrected CLP Form 8 semivolatile internal standard area summary including manually calculated limits for 1,4-dichlorobenzene-d4 that show the internal standard area for this compound was within quality control limits.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

# LLI #1212227 (SS-33)

The internal standard area reported for perylene-d12 was below the lower control limit at DF1. The internal standard area for this compound was within control limits when DF5 analysis was performed indicating a sample matrix problem.

Internal laboratory QA results indicated that other QA parameters tested for organic analyses were within control limits established in the project QA plan.

# LLI #1212228 (SS-34)

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

### LLI #1212229 (SS-35)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for 1,4-dichlorobenzene-d4. The laboratory sent a corrected CLP Form 8 including manually calculated limits for 1,4-dichlorobenzene-d4 that show the internal standard area for this compound was within quality control limits.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

### LLI #1212230 (SS-36)

PCB surrogate recovery was below the QC limit for oxychlordane. The negative result reported for PCBs will be flagged as a detection limit estimate (N).

DF5 results were reported for phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, and benzo(g,h,i)perylene. DF1 results were reported for all other compounds tested.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

### LLI #1212231 (SS-37)

PCB surrogate recovery was below the QC limit for oxychlordane. The negative result reported for PCBs will be flagged as a detection limit estimate (N).

The laboratory reported that the computer did not properly retrieve the internal standard area limits for 1,4-dichlorobenzene-d4. The laboratory sent a corrected CLP Form 8 including manually calculated limits for 1,4-dichlorobenzene-d4 that show the internal standard area for this compound was within quality control limits.

Internal laboratory QA results indicated that all QA parameters tested for organic analyses were within control limits established in the project QA plan.

### LLI #1212232 (SS-38)

Dilution factor one results were reported for all compounds tested. Internal standard areas for chrysene-d12 and perylene-d12 were below the lower QA limits at DF1. Internal standard areas were within QA limits when DF5 analysis was performed indicating a sample matrix problem.

Other laboratory QA parameters tested were within limits established in the project QA plan.

### LLI #317A Method Blank

All laboratory QA parameters tested were within limits established in the project QA plan. No target organic compounds or PCBs were detected in the method blank indicating laboratory analysis procedures did not introduce significant contamination to the sample.

Project File May 6, 1988
November 11, 1988

from: James Good, Quality Assurance Officer 55-1643-03 (0241A)

re: MEMORANDUM S8 QA Review: ASARCO RI, Surficial Soil Laboratory Results; Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1212583	SS-6 Unspiked Soil		11-23-87	12-07-87
1212584	SS-8	11-11-87	11-23-87	12-07-87
1212585	SS-3	11-11-87	11-23-87	12-07-87
1212586	SS-4	11-11-87	11-25-87	12-07-87
1212587	SS-16	11-11-87	11-24-87	12-07-87
1212588	Matrix Spike	••	11-24-87	12-07-87
1212589	Matrix Spike		11-24-87	12-07-87
1212590	Duplicate Method Blank		11-24-87	12-07-87

These surficial soil samples were collected on November 11, 1987 and received by the laboratory on November 13, 1987. The holding time to extraction for PCB analysis of these samples (12-14 days) exceeded the seven-day holding time established for water samples. Due to limited information concerning holding times for soil samples, the water holding time criterion was applied to soil samples. The percent relative standard deviation (% RSD) for sample peak response factors were less than 25 percent. Negative results will be flagged as detection limit estimates (N).

Matrix spiked recoveries exceeded QC limits for phenol and pentachlorophenol. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

# LLI #1212583 (SS-6 Unspiked Soil Sample)

to:

The semi-volatile internal standard area was less than the lower QC limit for chrysened12. The laboratory reported that the GC/MS analyst determined oil interference caused the low internal standard area and a dilution was not necessary. Results for compounds

quantitated using the internal standard chrysene-d12 (pyrene; butylbenzylphthalate; 3,3-dichlorobenzidine, benzo(a)anthracene, bis(2-ethylhexyl)phthalate; and chrysene) will be flagged as estimates (J or N).

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1212584 (\$S-8)

The moisture content result reported by the laboratory is the average moisture content of two aliquots of sample #1212584. The relative percent difference (RPD) between results of duplicate moisture anlayses was one percent.

Internal laboratory QA results indicated that internal standard area QC limits were exceeded for chrysene-d12. Manual integration of the internal standard had been omitted from the original data package. Amended forms sent by the laboratory indicate that the manually integrated internal standard area for chrysene-d12 was within QC limits.

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1212585 (SS-3)

The RPD between results of duplicate moisture analyses was two percent.

Semi-volatile internal standard areas were less than the lower QC limits for acenaphthene-d10, phenanthrene-d10, chrysene-d12, and perylene-d12. The laboratory stated that a DF10 sample was run for clarity and the results evidenced a sample matrix problem.

Other QA parameters tested were within control limits established in the project QA plan.

### LLI #1212586 (SS-4)

Matrix spiked recoveries exceeded QC limits for phenol and pentachlorophenol. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

## LLI #1212590 (Method Blank)

All other laboratory QA parameters tested were within established limits and the laboratory reported that all organic compounds and PCBs were less than detection limits in the method blank. The laboratory detected a trace (0.23 mg/kg) of bis(2-ethylhexyl)phthalate in the method blank. This compound was not detected in associated samples, thus no action was taken to qualify results.

JG:kjr

to: Project File May 9, 1988

Revised November 11, 1988 55-1643-03(0241A)

from: James Good, Quality Assurance Officer

re: MEMORANDUM S9 QA Review: ASARCO RI, Soil Laboratory Results;

Phase I Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1209940	SS-MW4-S-1	09-30-87	11-12-87	11-14-87
1209941	SS-MW5-S-1	09-29-87	11-12-87	11-14-87
1209942	SS-MW7-S-1	09-29-87	11-12-87	11-14-87
1209943	SS-MW8-S-1	10-01-87	11-12-87	11-14-87
1209944	SS-MW10-S-1	09-25-87	11-12-87	11-14-87
1209945	SS-MW11-S-1	09-22-87	11-12-87	11-14-87
1209946	SS-MW12-S-1	09-24-87	11-12-87	11-14-87
1209947	SS-MW12-S-1 Unspiked	09-21-87	11-12-87	11-14-87
1209948	Matrix Spike		11-27-87	11-13-87
1299949	Matrix Spike Duplicate		11-12-87	12-02-87
1209951	Method Blank		11-12-87	11-17-87

These soil samples collected in late September, 1987 were not delivered to the laboratory for analyses until November 2, 1987. Sample holding times from collection to extraction were 36 to 46 days for semi-volatile organic compounds and 43 to 53 days for PCBs. Thus, the 10-day holding times required by the EPA were exceeded for samples 1209940-1209947. The percent relative standard deviations (% RSD) of PCB sample peak response factors were less than 27 percent. All positive PCB and semi-volatile organics results reported for these samples will be flagged as estimated (J) and all negative results will be flagged as detection limit estimates (N).

The 12-hour GC/MS tuning frequency requirement was exceeded during the analysis of reinjected samples SS-MW4-S-1, SS-MW5-S-1, and the matrix spike sample. This was considered a minor departure from laboratory protocol and no action was taken to qualify results.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 9, 1988 Revised November 11, 1988 Page 2

## LLI #1209940 (SS-MW4-S-1)

The moisture content reported by the laboratory is the average moisture content of two aliquots of sample #1209940. The RPD between duplicate moisture anlayses was two percent.

The relative percent differences (RPDs) between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW4-S-1 will be flagged as an estimate (J).

Accuracy, as measured by semi-volatile organics spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to quality data.

Other QA parameters tested were within control limits established in the project QA plan.

## LLI #1209941 (SS-MW5-S-1)

The moisture content reported by the laboratory is the average moisture content of two aliquots of sample #1209941. The RPD between moisture content analyses was three percent.

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total concentration of both isomers.

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QA limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW5-S-1 will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Surrogate recovery of phenol-d5 (1 percent) was less than 10 percent for the semi-volatile analysis of sample 1209941. All positive results will be flagged as estimates (J) and all negative results will be flagged as unusable (R).

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 9, 1988
Revised November 11, 1988
Page 3

Other QA parameters tested were within the control limits established in the project QA plan.

### LLI #1209942 (SS-MW7-S-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total concentration of both isomers.

Dilution factor five (DF5) results were reported for all eight organic compounds detected in sample 1209942.

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW7-S-1 will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Semi-volatile internal standard areas were less than the lower QC limits for 1,4-dichlorobenzene-d4, naphthalene-d8, acenaphthene-d10, chrysene-d12, phenanthrene-d10, and perylene-d12. The laboratory reported that internal standard areas were within control limits following dilution and re-injection indicating there had been a sample matrix problem.

Other QA parameters tested were within control limits established in the project QA plan.

#### LLI #1209943 (SS-MW8-S-1)

Semi-volatile surrogate recoveries were less than QC limits for all compounds tested. Following re-extraction, all surrogate recoveries were within control limits.

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW8-S-1 will be flagged as a detection limit estimate (N).

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 9, 1988
Revised November 11, 1988
Page 4

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Semi-volatile internal standard areas were less than the lower QC limits for naphthalened8 and perylene-d12. Following re-extraction, all semi-volatile internal standard areas were within control limits.

Other QA parameters tested were within the control limits established in the project QA plan.

## LLI #1209944 (SS-MW10-S-1)

Semi-volatile surrogate recoveries were less than QC limits for all compounds tested. Following re-extraction, all surrogate recoveries were within control limits.

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW10-S-1 will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

The semi-volatile internal standard area was not reported for perylene-d12 and internal standard area QC limits were not reported for chrysene-d12 and pyrene-d12. An amended form submitted by the laboratory indicates that internal standard area data were complete and within control limits following re-injection of the sample.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1209945 (SS-MW11-S-1)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for 1,4-dichlorobenzene-d14 and perylene-d12. The laboratory sent a corrected form including manually calculated limits for 1,4-dichlorobenzene-d4 and perylene-d12 that indicated the internal standard areas for these compounds were within QC limits.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 9, 1988
Revised November 11, 1988
Page 5

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW11-S-1 will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Semi-volatile surrogate recoveries were below QC limits for 2-fluorophenol, phenol-d5, and 2-fluorobiphenyl indicating unacceptable laboratory performance. All semi-volatile organics results for sample SS-MW11-S-1 will be flagged as estimates (J or N).

Other QA parameters tested were within control limits established in the project QA plan.

## LLI #1209946 (SS-MW12-S-1)

Semi-volatile surrogate recoveries were less than QC limits for all compounds tested. Following re-extraction, all surrogate recoveries were within control limits.

RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for sample SS-MW12-S-1 will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

# LLI #1209947 (SS-MW12-S-1, Unspiked Soil Sample)

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for the unspiked soil sample will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 9, 1988 Revised November 11, 1988 Page 6

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1209951 (Method Blank)

The RPDs between matrix spiked and duplicate matrix spiked samples exceeded QC limits for the PCBs aroclor 1242 and aroclor 1260. The PCB result for this method blank will be flagged as a detection limit estimate (N).

Accuracy, as measured by spike recoveries, was observed to exceed laboratory control limits for phenol, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Other QA parameters tested were within limits established in the project QA plan. No target organic compounds or PCBs were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination of samples.

APPENDIX R

FERENCE CELECTER CONTRACTOR

SURFACE WATER
QUALITY ASSURANCE MEMORANDA

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to: Project File

June 20, 1988 Revised February 6, 1989

from:

James Good, Quality Assurance Officer

55-1643-03(0241A)

re:

QA Review: ASARCO RI, Surface Water Laboratory Results, Round 1;

Metals and TSS

This QA review includes the following samples analyzed by ASARCO for metals and total suspended solids (TSS):

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
88-1111	SP-1 (seep grab)	01-28-88	03-17-88
88-1112	SP-2 (seep grab)	01-28-88	03-17-88
88-1113	SP-4 (seep grab)	01-28-88	03-17-88
88-1114	SP-5 (seep grab)	01-28-88	03-17-88
88-1115	2°A (outfall grab)	01-28-88	03-17-88
88-1116	2°B (outfall grab)	01-28-88	03-17-88
88-1117	2°C (outfall grab)	01-28-88	03-17-88
88-1118	2°D (outfall grab)	01-28-88	03-17-88
88-1119	SW-7 (composite)	01-28-88	03-17-88
88-1120	SW-1 (composite)	01-28-88	03-17-88
88-1121	SW-2 (composite)	01-28-88	03-17-88
88-1122	SW-8 (composite)	01-28-88	03-17-88
88-1123	SW-3 (composite)	01-28-88	03-17-88
88-1124	SW-4 (composite)	01-28-88	03-17-88
88-1125	SW-13 (composite)	01-28-88	03-17-88
88-1126	SW-5 (composite)	01-28-88	03-17-88
88-1127	SW-6 (composite)	01-28-88	03-17-88
88-1128	SW-12 (composite)	01-28-88	03-17-88
88-1129	SW-11 (composite)	01-28-88	03-17-88
88-1130	SW-9 (composite)	01-28-88	03-17-88
88-1131	SW-13 (duplicate)	01-28-88	03-17-88
88-1132	SW-70 (field blank)	01-28-88	03-17-88
88-1133	SW-10 (composite)	01-28-88	03-28-88

to: Project File from: James Good, Quality Assurance Officer June 20, 1988
Revised February 6, 1989
Page 2

These surface water samples were collected on January 28 and received by the laboratory on February 1, 1988. Total suspended solids were analyzed on February-3. Mercury was analyzed well within the 28-day holding time requirement and all metals analyses were completed well within the six-month limit.

The quality control sample frequency of five percent specified in the Quality Assurance Plan was generally achieved for surface water metals analyses. No blanks were analyzed with the graphite furnace analysis of lead, thus the positive dissolved lead results for samples SW-1, SP-5, and SW-11 will be flagged as estimates (J).

The percent recovery of dissolved lead (116 percent) exceeded the 110 percent control limit for the continuing calibration verification of reference sample WP386 in cup #17 of the graphite furnace analysis. This indicates the positive dissolved lead result for sample SW-1 may be biased high and provides further evidence for qualifying it as estimated.

The laboratory flagged the furnace AA dissolved lead result for sample SW1 with a "W" according to CLP protocol because the spike recovery (138 percent) exceeded the 115 percent quality control limit. The "W" flag will be changed to "J" to comply with Data Validation Guidelines.

No metals were detected in laboratory blanks or in the field blank indicating significant contamination of samples did not occur.

The relative percent differences (RPDs) between laboratory duplicate analyses were all less than the 20 percent quality control limit indicating acceptable analytical precision. Overall precision was measured by the RPDs between field duplicate samples. The RPD for total lead results in field duplicate samples of SW-13 exceeded 20 percent and the difference for cadmium exceeded ±CRQL. Quality control limits were not applied to field duplicate RPDs. These results may reflect a high degree of variability in metals content at this sampling site.

Other laboratory QA parameters tested were within the limits established in the QA/QC protocol agreement.

JG:kjr

Project File January 17, 1989
Revised January 31, 1989

Issue: Cond. Outsite: Assurance Officer.

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

to:

re: QA Review: ASARCO RI, Surface Water Laboratory Results, Round 2; Metals and TSS

This QA review includes the following samples analyzed by ASARCO for metals and total suspended solids (TSS):

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
88-2056	SW-5 (composite)	03-22-88	05-19-88
88-2057	SW-6 (composite)	03-22-88	06-23-88
88-2058	SW-10 (composité)	03-22-88	06-23-88
88-2059	SW-11 (composite)	03-22-88	06-23-88
88-2060	SW-70 (Rinsate Blank)	03-22-88	06-23-88
88-2061	SW-13 (composite)	03-22-88	06-23-88
88-2062	SW-7 (composite)	03-22-88	05-19-88
88-2063	SW-1 (composite)	03-22-88	06-23-88
88-2064	SW-2 (composite)	03-22-88	06-23-88
88-2065	SW-3 (composite)	03-22-88	06-23-88
88-2066	SW-4 (composite)	03-22-88	06-23-88
88-2067	SW-9 (composite)	03-22-88	05-19-88
88-2068	SW-12 (composite)	03-22-88	06-23-88
88-2069	DUP (duplicate of SW-13)	03-22-88	06-24-88
88-2070	SP-1 (seep grab)	03-22-88	06-23-88
88-2071	SP-3 (seep grab)	03-22-88	06-23-88
88-2072	SP-5 (seep grab)	03-22-88	06-23-88
88-2073	SP-2 (seep grab)	03-22-88	06-24-88
88-2074	SP-4 (seep grab)	03-22-88	06-24-88
88-2075	SW-11G (grab)	03-22-88	06-24-88
88-2076	A (outfall grab)	03-22-88	06-24-88

to:

Project File

from:

James Good, Quality Assurance Officer

January 17, 1989

Revised January 31, 1989

Page 2

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
88-2077	B (outfall grab) C (outfall grab) D (outfall grab) E (outfall grab)	03-22-88	05-19-88
88-2078		03-22-88	06-24-88
88-2079		03-22-88	06-24-88
88-2080		03-22-88	05-19-88

These surface water samples were collected on March 22 and received by the laboratory on March 24, 1988. Total suspended solids were analyzed on March 29. Mercury was analyzed well within the 28-day holding time requirement and all metals analyses were completed well within the six-month limit.

The quality control sample frequency of five percent specified in the Quality Assurance Plan was generally achieved for surface water metals analyses. The frequency of blank analyses was only four percent for mercury, cadmium, copper and zinc; and only two percent for antimony. No blanks were tested with the flame AA analysis of arsenic, thus the total arsenic results quantitated for the following samples will be flagged as estimates (J): SW-5, SW-10, SW-11, SW-12, "A" outfall, "D" outfall, and the dissolved arsenic in SW-11. One field duplicate sample and one rinsate blank were collected and analyzed for a frequency of four percent.

Dissolved copper (13 ppb) and dissolved zinc (28 ppb) were detected in the rinsate blank sample SW-70 although total copper and total zinc were not detected in the rinsate. The contamination probably occurred during sample filtration in the ASARCO Tacoma laboratory where samples were exposed to dust. The filtering was performed by the Parametrix field crew prior to sample shipment. Dissolved copper and dissolved zinc were detected in the following samples at less than five times the blank concentrations and will be flagged as estimates (J): SW-13, SW-2, SW-4, SW-13FD, SP-1, SP-3, SP-5, and SP-2. Additionally, dissolved zinc results for the following samples will be flagged as estimates (J): SW-6, SW-7, SW-1, SW-3, SP-4, and A.

The relative percent differences (RPDs) between field duplicate results for SW-13 and SW-13FD exceeded 20 percent for dissolved arsenic (31 percent) and total arsenic (38) percent indicating low overall precision. The difference between total zinc results (16 ppb) exceeded  $\pm$  the detection limit (8 ppb). Quality control limits were not applied to field duplicate RPDs, thus no action was taken to qualify sample data.

The laboratory flagged the total and dissolved lead results (E) for the graphite furnace AA analysis of sample SW-11G due to low spike recovery in accordance with USEPA CLP protocol. The qualifier was changed to a "N" to comply with Data Validation Guidelines.

to:

from:

Project File James Good, Quality Assurance Officer

January 17, 1989

Revised January 31, 1989

Page 3

Other laboratory QA parameters tested were within the limits established in the QA/QC protocol agreement.

JG:kjr

Project File January 20, 1989

Revised January 31, 1989

from: James Good, Quality Assurance Officer Revised January 31, 1989 55-1643-03 (0241A)

re: QA Review: ASARCO RI, Surface Water Laboratory Results, Round 3;

Metals and TSS

to:

This QA review includes the following samples analyzed by ASARCO for metals and total suspended solids (TSS):

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
88-4039 88-4040	SW-1 (Composite)	06-01-88	07-19-88 07-19-88
88-4041	SW-2 (Composite) SW-3 (Composite)	06-01-88 06-01-88	07-19-88
88-4042	SW-4 (Composite)	06-01-88	07-19-88
88-4043	SW-5 (Composite)	06-01-88	07-19-88
88-4044	SW-6 (Composite)	06-01-88	07-19-88
88-4045	SW-7 (Composite)	06-01-88	07-19-88
88-4046	SW-9 (Composite)	06-01-88	07-19-88
88-4047	SW-10 (Composite)	06-01-88	07-19-88
88-4048	SW-11 (Composite)	06-01-88	07-13-88
88-4049	SW-11B (grab)	06-01-88	07-13-88
88-4050	SW-12 (Composite)	06-01-88	07-19-88
88-4051	SW-13 (Composite)	06-01-88	07-19-88
88-4052	SW-14 (Duplicate of SW-13)	06-01-88	07-19-88
88-4053	SW-15 (Rinsate Blank)	06-01-88	07-19-88
88-4054	SEC A (Outfall grab)	06-01-88	07-19-88
88-4055	SEC B (Outfall grab)	06-01-88	07-13-88
88-4056	SEC C (Outfall grab)	06-01-88	07-19-88
88-4057	SEC D (Outfall grab)	06-01-88	07-13-88
88-4058	SEEP 1 (grab)	06-01-88	07-19-88
88-4059	SEEP 2 (grab)	06-01-88	07-19-88
88-4060	SEEP 4 (grab)	06-01-88	07-19-88
88-4061	SEEP 5 (grab)	06-01-88	07-19-88

to:

Project File

from:

James Good, Quality Assurance Officer

January 20, 1989

Revised January 31, 1989

Page 2

These surface water samples were collected June 1 and received by the laboratory on June 3, 1988. Total suspended solids were analyzed on June 6. Mercury was analyzed well within the 28-day holding time requirement and all metals analyses were completed well within the six-month limit.

The quality control sample frequency of five percent specified in the Quality Assurance Plan was achieved for all analyses.

The initial calibration verification (ICV) recovery of antimony in the laboratory control sample ERA 9916 (88 percent) was outside the  $\pm$  10 percent control limits. All positive antimony results will be flagged as estimates (J) and all negative antimony results will be flagged as detection limit estimates (N).

Dissolved zinc (15 ppb) and total zinc (8.0 ppb) were detected in the rinsate blank sample SW-15. Dissolved zinc results for SW-2, SW-7, SW-13, SW-14, SEEP 1, SEEP 2, and SEEP 4 were less than five-times the blank concentration and will be flagged as estimates (J or N). Total zinc results for SW-13, SW-14, Seep 1, and Seep 2 were less than five-times the blank concentration and will also be flagged as estimates (J).

Twenty-seven samples were analyzed for total and dissolved lead by graphite furnace atomic absorption spectraphotometry. Spike recoveries of dissolved lead in samples SW-6 (122.8 percent) and SEEP 5 (83.9 percent) were outside the ± 15 percent quality control limits. The laboratory flagged dissolved lead results for these two samples "W" in accordance with CLP protocol. The "W" flags will be replaced by "J" qualifiers to comply with Data Validation Guidelines.

The laboratory reported that the TSS results for SW-1 and SW-2 were "lost in analysis", thus there are no TSS results for these two samples.

Field notes indicated that sample SW-11 was a composite sample influenced by tide waters and SW-11B was a grab sample not affected by tides.

The laboratory reported that dissolved zinc exceeded total zinc concentrations in samples SW6, SW-13, SW-15, SEEP 1, and SEEP 2. These results were confirmed by both repeat analyses and direct aspiration of undigested samples.

Other laboratory QA parameters tested were within the limits established in the QA/QC protocol agreement.

JG:kjr 2188 to: Project File 55-1643-03(0241A)

from: James Good, Quality Assurance Officer March 1, 1989

re: QA Review: ASARCO RI, Tunnel Seep Surface Water Laboratory Results;
Total Metals

This QA review includes the following tunnel seep samples analyzed by ASARCO for total metals:

ASARCO I.D.	Parametrix I.D.	Date Sampled	Date Analyzed
89-1	Seep-A	12-19-88	02-02-89
89-2	Seep-B	12-19-88	02-02-89

These tunnel seep samples were collected on December 19, 1989 and received by the laboratory on January 5, 1989. Mercury was analyzed on January 27, thus exceeding the 28-day holding time requirement. Mercury results will be flagged as estimates (J or N). All other metals analyses were completed well within the six-month holding time limit.

The arsenic result for sample Seep-A was incorrectly calculated as 255 ppm in the raw data but correctly reported as 1530 ppm in the sample analysis report. No other errors were detected and all QA parameters tested were within control limits. No action was taken to qualify tunnel seep data except mercury results flagged due to holding time violations.

JG:kjr

to: Project File

January 31, 1989

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

Revised: March 2, 1989

re:

MEMO # SW-1

QA review: ASARCO RI/FS, Surface Water Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster	Parametrix <u>I.D. #</u>	Sample Date	Extraction Date	Analysis Date
1232734	SP-4	1/28/88	2/03/88	2/04/88
1232735	SP-2	1/28/88	2/03/88	2/04/88
1232736	SP-1	1/28/88	2/03/88	2/04/88
1232737	SEC-A	1/28/88	2/08/88	2/12/88
1232738	SP-5	1/28/88	2/03/88	2/04/88
1232739	SEC-B	1/28/88	2/03/88	2/05/88
1232740	SW-7	1/28/88	2/03/88	2/05/88
1232741	SEC-D	1/28/88	2/03/88	2/09/88
1232742	SEC-C	1/28/88	2/03/88	2/09/88
1232743	SW-1	1/28/88	2/03/88	2/09/88
1232744	SW-8	1/28/88	2/03/88	2/09/88
1232745	SW-2	1/28/88	2/03/88	2/08/88
1232746	SW-3	1/28/88	2/03/88	2/08/88
1232747	SW-4	1/28/88	2/03/88	2/08/88
1232748	SW-13	1/28/88	2/03/88	2/09/88
1232749	SW-6	1/28/88	2/03/88	2/09/88
1232750	SW-12	1/28/88	2/03/88	2/09/88
1232751	SW-11	1/28/88	2/03/88	2/09/88
1232752	SW-9	1/28/88	2/03/88	2/09/88
1232753	SW-13FD	1/28/88	2/03/88	2/11/88
1232754 S	W-70 Field Blank	1/28/88	2/03/88	2/09/88
1231754	Method Blank		2/03/88	2/05/88
BG DAY 34A	Unspiked		2/03/88	2/04/88
MS DAY 34A	M. Špike	•••	11/9/87	11/25/87
MSD DAY 34	A M.S.Dup.		11/9/87	11/25/87

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

These surface water samples were collected on 1/28/88 and generally extracted within the seven day limit and analyzed within the 40 day limit. The exceptions were samples 1232737 (SEC-A) and 1232754 (Field Blank) which were re-extracted after the seven day limit. The limits were not grossly exceeded so no qualifications are deem necessary.

The percent recovery and the relative percent difference (RPD) between the matrix spike and matrix spike duplicate samples fell within the QC limits for all eleven spike compounds.

Three tentatively identified compounds were detected in the Method Blank as well as in all or most of the samples (at approximately the same concentrations). These compounds are 1,13-Tetradecadiene, Dichloromethane, and Tetrahydrofuran. However no target list compounds were found in the blank so no action is deemed necessary.

bis(2-ethylhexyl)phthalate was detected at 52.9 mg/l in the unspiked sample but not detected in the Matrix Spike or the Matrix Spike Duplicate samples. Since Matrix Spike results are used for long-term evaluation of the laboratory precision and accuracy no qualification to the data set is needed.

All other laboratory QA parameters tested were within the limits established in the project QA plan.

#### LLI# 1232734 (SP-4)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232735 (SP-2)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232736 (SP-1)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

### LLI# 1232737 (SEC-A)

This sample had to be re-extracted because surrogate recoveries of 2-Fluorophenol, Terphenyl-d14, and Nitrobenzene-d5 were below the QA/QC limits and the internal standard area for Perylene was also out of limits. This re-extraction occurred beyond the seven day limit for holding time (15 days). Since the holding time was not grossly exceeded no qualifications are deemed necessary.

There was no internal standard area summary sheet for the re-extraction so one was requested from the laboratory. All the other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

## LLI# 1232738 (SP-5)

The internal standard area for Perylene was below QA/QC limits for this sample. Therefore the following undetected compounds will be flagged as undetected at the estimated detection limit (N).

Di-n-octyl Phthalate Benzo(k)fluoranthene Indeno(1,2,3-cd)pyrene Benzo(g,h,i)perylene Benzo(b)fluoranthene Benzo(a)pyrene Dibenzo(a,h) anthracene

All the other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

### LLI# 1232739 (SEC-B)

The internal standard area for Perylene was below QA/QC limits for this sample. Therefore the following undetected compounds will be flagged as undetected at the estimated detection limit (N).

Di-n-octyl Phthalate Benzo(k)fluoranthene Indeno(1,2,3-cd)pyrene Benzo(g,h,i)perylene Benzo(b)fluoranthene Benzo(a)pyrene

Dibenzo(a,h) anthracene

All the other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 4

#### LLI# 1232740 (SW-7)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

# LLI# 1232741 (SEC-D)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232742 (SEC-C)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

### LLI# 1232743 (SW-1)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

### LLI# 1232744 (SW-8)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

## LLI# 1232745 (SW-2)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232746 (SW-3)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 5

### LLI# 1232747 (SW-4)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

### LLI# 1232748 (SW-13)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232749 (SW-6)

Due to an insufficient sample volume, the detection limits were higher than usual. All the other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232750 (SW-12)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

### LLI# 1232751 (SW-11)

Due to an insufficient sample volume, the detection limits were higher than usual. All the other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1232752 (SW-9)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 6

# LLI# 1232753 (SW-13FD)

No compounds were detected in either the sample or the duplicate so RPDs could not be calculated. All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

# LLI# 1232754 (Field Blank)

On the first analysis of the field blank the surrogates were not included so the sample was re-extracted. This re-extraction exceeded the QA/QC holding time limits. The surrogate recovery of 2-Fluorophenol and Nitrobenzene were low for the subsequent analysis so the sample was re-analyzed. Since no compounds were detected in any of the sample runs, no qualifications are necessary.

to: Project File February 2, 1989 55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re: MEMO # SW-2

QA review: ASARCO RI/FS, Surface Water Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix I.D. #	Sample Date	Extraction Date	Analysis Date
1248419	SW-5	3/22/88	3/30/88	4/05/88
1248420	SW-6	3/22/88	3/30/88	4/05/88
1248421	SW-10	3/22/88	3/30/88	4/05/88
1248682	SW-11	3/22/88	3/30/88	4/05/88
1248683	SW-70 Field Dup	3/22/88	3/30/88	4/05/88
1248934	Method Blank	***	2/03/88	2/05/88
<b>BG DAY 089</b>	Unspiked		2/03/88	2/04/88
MS DAY 089	M. Spike	• •••	2/03/88	2/04/88
MSD DAY 08	89 M.S.Dup.		2/03/88	2/04/88

These surface water samples were collected on 3/22/88 and extracted 8 days after sampling which exceeds the seven day holding time limit. Since this did not grossly exceed the holding time limits, no qualifications are needed for the results. Samples were analyzed within the 40 day limit.

The percent recovery of 2,4-Dinitrotoluene in the Matrix Spike sample was 100% which exceeded the upper QA/QC limit of 96%. However, the relative percent difference (RPD) between the matrix spike and matrix spike duplicate samples fell within the QC limits for all eleven spike compounds. Since the MS/MSD samples are used to examine the long-term precision and accuracy of the analytical procedure no qualification to this data is appropriate.

One tentatively identified compound (1,13-Tetradecadiene) was detected in the Method Blank as well as all the samples (at approximately the same concentrations). However, since no target list compounds were found in the blank so no action is deemed necessary.

All other laboratory QA parameters tested were within the limits established in the project QA plan.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

#### LLI# 1248419 (SW-5)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1248420 (SW-6)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

# LLI# 1248421 (SW-10)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

# LLI# 1248682 (SW-11)

Due to the insufficient volume of this sample, the detection limits were higher than in other samples. All the other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

## LLI# 1248683 (Field Blank)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

OOO APPENDIX S

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SURFICIAL MARINE SEDIMENT QUALITY ASSURANCE MEMORANDA

to: Project File January 9, 1989
Revised January 31, 1989

from: James Good, Quality Assurance Officer 55-1643-03(0241A)

re: QA Review: ASARCO RI, Marine Sediment Laboratory Results: Phase I Total Metals

This QA review includes the following marine sediment samples analyzed by ASARCO for total metals:

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
87-9551	MSM-10-1	10-27-87	1-26-88
87-9552	MSM-10-2	10-27-87	2-2-88
87-9553	MSM-10-3	10-27-87	2-2-88
87-9554	MSM-10-4	10-27-87	2-2-88
87-9555	MSM-9-8	10-27-87	2-2-88
87-9556	MSM-9-7	10-27-87	2-2-88
87-9557	MSM-9-6	10-27-87	2-2-88
87-9598	MSM-9-1	10-28-87	1-26-88
87-9599	MSM-9-2	10-28-87	2-2-88
87-9600	MSM-11-2	10-28-87	2-2-88
87-9601	MSM-11-3	10-28-87	2-2-88
87-9602	MSM-11-9	10-28-87	2-2-88
87-9603	MSM-11-8	10-28-87	2-2-88
87-9604	MSM-11-7	10-28-87	2-2-88
87-9605	MSM-11-6	10-28-87	2-2-88
87-9621	MSM-11-5	10-29-87	2-2-88
87-9622	MSM-11-4	10-29-87	2-2-88
87-9623	MSM-9-3	10-29-87	2-2-88
87-9624	MSM-9-4	10-29-87	2-2-88
87-9625	MSM-9-5	10-29-87	2-2-88
87-9626	MSM-13-8	10-29-87	2-2-88
87-9627	MSM-13-7	10-29-87	2-2-88
87-9628	MSM-7-7	10-29-87	2-2-88
87-9629	Rep. 1	10-29-87	2-2-88
87-9841	MSM-13-6	11-03-87	2-2-88
87-9842	MSM-13-5	11-03-87	2-2-88

to: Project File from: James Good, Quality Assurance Officer January 9, 1989
Revised January 31, 1989
Page 2

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
87-9843	MSM-13-4	11-03-87	2-2-88
87-9844	MSM-13-2	11-03-87	2-2-88
87-9845	MSM-13-3	11-03-87	2-2-88
87-9926	MSM-14-5	11-04-87	2-2-88
87-9927	MSM-14-4	11-04-87	2-2-88
87-9928	MSM-15-5	11-04-87	2-2-88
87-9929	MSM-15-4	11-04-87	2-2-88
87-9930	MSM-12-5	11-04-87	2-2-88
87-9932	MSM-12-4	11-04-87	2-2-88
87-9933	MSM-10-0	11-04-87	1-26-88
87-9934	MSM-11-1	11-04-87	1-26-88
87-9993	MSM-14-3	11-06-87	2-2-88
87-9994	MSM-14-2	11-06-87	2-2-88
87-9995	MSM-15-3	11-06-87	2-2-88
87-9996	MSM-15-2	11-06-87	2-2-88
87-9997	MSM-12-2	11-06-87	2-2-88
87-9998	MSM-12-3	11-06-87	2-2-88
87-10070	MSM-7-6	11-09-87	2-2-88
87-10071	MSM-7-5	11-09-87	2-2-88
87-10072	MSM-7-4	11-09-87	2-2-88
87-10073	MSM-7-3	11-09-87	1-26-88
87-10074	MSM-8-4	11-09-87	2-2-88
87-10075	MSM-8-3	11-09-87	2-2-88
87-10076	MSM-7-2	11-09-87	1-26-88
87-10077	MSM-8-2	11-09-87	1-26-88
87-10078	MSM-8-1	11-09-87	1-26-88
87-10109	MSM-7-1	11-10-87	1-26-88
87-10110	MSM-6-4	11-10-87	2-2-88
87-10111	MSM-6-3	11-10-87	1-26-88
87-10112	MSM-6-1	11-10-87	1-26-88
87-10113	MSM-6-2	11-10-87	1-26-88
87-10114	MSM-5-3	11-10-87	1-26-88
87-10115	MSM-5-2	11-10-87	1-26-88
87-10136	MSM-16-4	11-11-87	2-2-88
87-10137	MSM-16-3	11-11-87	2-2-88
87-10138	MSM-16-2	11-11-87	2-2-88
87-10139	MSM-16-1	11-11-87	2-2-88
87-10140	MSM-17-4	11-11-87	2-2-88

to: Project File from: James Good, Quality Assurance Officer January 9, 1989
Revised January 31, 1989
Page 3

ASARCO I.D.	Parametrix I.D.	Sample Date	Analysis Date
87-10141	MSM-17-3	11-11-87	2-2-88
87-10142	MSM-17-2	11-11-87	2-2-88
87-10143	MSM-17-1	11-11-87	2-2-88
87-10144	MSM-18-2	11-11-87	2-2-88
87-10145	MSM-18-1	11-11-87	2-2-88
87-10146	Rep. 3	11-11-87	2-2-88
87-10168	MSM-19-2	11-12-87	2-2-88
87-10169	MSM-19-1	11-12-87	2-2-88
87-10170	MSM-20-1	11-12-87	2-2-88
87-10171	MSM-20-2	11-12-87	2-2-88
87-10172	MSM-18-3	11-12-87	2-2-88
87-10173	MSM-4-3	11-12-87	1-26-88
87-10273	MSM-13-1	11-17-87	1-26-88
87-10274	MSM-12-1	11-17-87	1-26-88
87-10433	MSM-2-3	11-18-87	2-2-88
87-10434	MSM-3-3	11-18-87	2-2-88
87-10435	MSM-3-2	11-18-87	1-26-88
87-10436	MSM-3-1	11-18-87	1-26-88
87-10437	MSM-4-0	11-18-87	1-26-88
87-10438	MSM-4-2	11-18-87	1-26-88
87-10515	MSM-4-1	11-19-87	1-26-88
87-10516	MSM-5-1	11-19-87	1-26-88
87-10517	MSM-5-0	11-19-87	2-2-88
87-10518	Rep. 4	11-19-87	1-26-88
87-10519	MSM-21-1	11-20-87	2-2-88
87-10520	MSM-21-2	11-20-87	2-2-88
87-10521	MSM-21-3	11-20-87	2-2-88
87-10522	MSM-14-1	11-20-87	1-26-88
87-10523	MSM-6-0	11-20-87	2-2-88
87-10691	MSM-22-1	11-25-87	2-2-88
87-10692	MSM-22-22	11-25-87	2-2-88
87-10693	MSM-22-3	11-25-87	2-2-88
87-10694	MSM-2-1	11-25-87	2-2-88
87-10695	MSM-2-2	11-25-87	2-2-88
87-10696	MSM-0-1	11-25-87	2-2-88
87-10697	MSM-0-2	11-25-87	2-2-88
87-10698	MSM-0-3	11-25-87	2-2-88
87-10699	MSM-1-1	11-25-87	2-2-88

to:

Project File

from:

James Good, Quality Assurance Officer

January 9, 1989

Revised January 31, 1989

Page 4

These marine sediment samples were collected between October 27 and November 25, 1988. All metals analyses were completed within the six-month holding time requirement for arsenic, copper, lead and zinc. The laboratory reported that the custody seals on sample containers were in deteriorated condition upon arrival at the laboratory. The seal was broken on the container for sample MSM-13-7 nd the jar lid was not tight.

The quality control sample frequency of five percent called for in the Quality Assurance Plan was not achieved for all marine sediment analyses. At least five field duplicates, laboratory duplicates, reagent blanks, laboratory control samples, and matrix spikes should have been analyzed to meet the five percent minimum for the 99 samples. Only three field duplicate samples were analyzed for total metals. A fourth field duplicate (Rep. 2) was sent to another laboratory for radiological analysis.

No spike analyses or reagent blank analyses were run with the flame atomic absorption analysis of arsenic. Also, no laboratory duplicates were run with the hydride generation flameless AA analysis of arsenic. All arsenic results will be flagged as estimates (J) due to the insufficient quality control information regarding possible sample contamination, analytical accuracy and analytical precision.

Four spiked samples were analyzed for copper, lead and zinc on January 26 and 27 along with several spiked blanks. Results of five spiked blanks were included for the February flameless AA analysis of arsenic. ASARCO marine sediment samples were again used for spike analyses on March 2, but these results do not apply to earlier laboratory tests. The lead result for MSM-14-3 (1.30 ug/ml) was incorrectly reported as 0.91 ug/ml on the spike sample recovery report, and the correct spike recovery was 93 percent.

The laboratory reported that samples MSM-6-2 and MSM-13-1 were unsuitable for spike analyses. Post digestion spike analyses were performed on both samples and all spike recoveries were within the  $\pm 15$  percent control limit.

The relative percent differences (RPDs) between metals results for sample MSM-4-1 and the field duplicate Rep. 4 were less than 25 percent. The RPDs between arsenic results for MSM-9-5 and Rep. 1 (32 percent) and between MSM-16-4 and Rep. 3 (48 percent) exceeded 25 percent indicating low overall precision.

All RPDs calculated for internal laboratory duplicate analyses were within the 25 percent control limit demonstrating acceptable analytical precision. The zinc result for MSM-1-1 (118 ppm) was incorrectly reported as 128 ppm on the duplicate sample analysis report, thus the correct RPD value was 8.1 percent.

to:

Project File

from:

James Good, Quality Assurance Officer

January 9, 1989

Revised January 31, 1989

Page 5

Metals were not detected in any reagent blanks indicating significant sample contamination did not occur in the laboratory.

The initial calibration verification (ICC) percent recoveries of arsenic in the analyses of standard WP886-1 (71 and 72 percent) fell outside the 90 to 100 percent acceptance window indicating the flameless atomic absorption instrument was not properly calibrated for arsenic. Three of the six continuing calibration verification recoveries were also outside the  $\pm 10$  percent acceptance window. These results provided further evidence for flagging arsenic data as estimates (J). ICV reports dated March 2, 1988 are not associated with ASARCO marine sediment analyses.

AT least one laboratory control sample (LCS) was run at the beginning of each metal analysis, and additional reference samples were sometimes run at the end of an analysis. The laboratory inadvertently included two lead results for reference sample NBS-1645, lead and zinc results for In-house Q.C. #52, and a lead result for In-house Q.C. #89 that were associated with the analysis of soil samples. Also, the lead result reported for NBS-1648 (6487 ppm) was associated with the soils analysis. The correct result associated with marine sediment samples was 6850 ppm, still within quality control limits for LCS recovery. Reference sample results dated March 2, 1988 are not associated with ASARCO marine sediment analyses.

Other QA parameters were within limits established in the project QA plan.

JG:kjr

from: James Good, Quality Assurance Officer February 13, 1989

re: QA Review: ASARCO RI, Phase II Marine Sediment Laboratory Results;
Total Metals

This QA review includes the following marine sediment samples analyzed by ASARCO for total metals:

ASARCO I.D.	Parametrix I.D.	Date Sampled	Date Analyzed
88-4300	T16-4	06-30-88	08-11-88
88-4599	T16-1	07-06-88	08-11-88
88-4600	T12-1	07-06-88	08-10-88
88-4601	T5-0	07-07-88	08-10-88
88-4602	T18-2	07-07-88	08-11-88
88-4603	T10-1	07-07-88	08-10-88
88-4604	T10-2	07-07-88	08-11 <b>-8</b> 8
88-4605	T11-7	07-07-88	08-11-88
88-4606	T8-4	07-08-88	08-11 <b>-</b> 88
88-4607	T6-3	07-08-88	08-10-88
88-4608	T6-1	07-08-88	08-10-88
88-4619	T4-2	07-11-88	08-10-88
88-4620	T4-2	07-12-88	08-10-88
88-4621	T3-2	07-12-88	08-10-88
88-4623	T14-2	07-11-88	08-11 <b>-</b> 88
88-4624	T4-1	07-11-88	08-10-88
88-4625	T15-1	07-12-88	08-10-88
88-4626	T3-20 Duplicate	07-12-88	08-10-88
88-4630	T22-1	07-13-88	08-11-88
88-4631	T22-2	07-13-88	08-11-88
88-4632	T4-4	07-13-88	08-11 <b>-</b> 88
88-4637	T3-6	07-14-88	08-10-88
88-4638	T3-5	07-14-88	08-10-88
88-4639	T3-4	07-14-88	08-10-88
88-4640	T2-5	07-14-88	08-11-88
88-4700	T2A-5	07-15-88	08-10-88
88-4702	T2-6	07-15-88	08-11-88
88-4703	T2-60 Duplicate	07-15-88	08-11-88
88-4837	T4-1 Combined	07-22-88	08-10-88

to: from: page 2	Project File James Good, Quality Assuran	nce Officer	55-1643-03(0241A) February 13, 1989
88-4838 88-4839 88-4840 88-4841 88-4842 88-4843 88-4844 88-4845 88-4846	T4-1 Separated slag T4-1 Mixed T4-1 Native T4-2 Combined T4-2 Separated slag T4-2 Mixed T4-2 Native T14-2 Combined T14-2 Separated slag	07-22-88 07-22-88 07-22-88 07-22-88 07-22-88 07-22-88 07-22-88 07-22-88	08-10-88 08-10-88 08-10-88 08-10-88 08-10-88 08-10-88 08-11-88
88-4847 88-4848 88-4849 88-4850 88-4851 88-4852 88-4890 88-4891 88-4892 88-4893	T14-2 Mixed T14-2 Native T15-1 Combined T15-1 Separated slag T15-1 Mixed T15-1 Native T0-2 T0-3 T1-1 T2-1	07-22-88 07-22-88 07-22-88 07-22-88 07-08-88 07-08-88 08-01-88 08-01-88 08-01-88	08-11-88 08-11-88 08-10-88 08-10-88 08-10-88 10-13-88 10-07-88 10-13-88 10-13-88

These marine sediment samples were collected between June 30 and August 1, 1988, and received by the laboratory one to four days following collection. The holding times between sample collection and analysis for mercury ranged from 32 to 41 days for samples 88-4300 and 88-4599 through 88-4608. The holding times for mercury were 71 days for samples collected on August 1, 1988. The total mercury results for these samples will be flagged as estimates (J or N) because the 28-day maximum holding time was exceeded.

The laboratory reported that samples T2A-5, T2-6, and T2-60 were warm when they arrived. Total metals results for these samples will be flagged as estimates (J or N) due to inadequate sample preservation.

The Initial Calibration Verification (ICV) recovery for the hydride generation analysis of arsenic (89 percent) was less than the 90 percent control limit. This violation of the control limit may have been due to a rounding error, thus no action was taken to qualify sample data. On the original ICV form send by the laboratory, the mercury ICV results from October 11 were missing, and a zinc result for In-House QC #100 was included that did not appear in the raw data. A corrected ICV form was sent by the laboratory.

Reagent blank results from the October 11 analysis of mercury were missing from the blank analysis form. The laboratory sent a corrected form including the missing data.

to:

Project File

from:

James Good, Quality Assurance Officer

55-1643-03(0241A) February 13, 1989

page 3

Matrix spike analysis reports were missing results for mercury in sample T11-7, mercury and copper in T14-2; and mercury, copper and lead in T2-60. The matrix spike recovery of mercury in sample T14-2 was negative indicating mercury results for associated samples may be biased low. Mercury results for samples T4-4, T3-6, T3-5, T3-4, T2-5, T2A-5, T2-60 and T4-1 combined were flagged as estimated (J).

The copper results for samples T4-1 combined and T4-2 combined and the lead result for T4-1 mixed were quantitated using portions of the calibration curves that did not encompass the sample absorbances. The laboratory recalculated these results using curves with broader ranges of absorbances and sent corrected forms.

A review of the raw data and calculations turned up two data reduction errors that were corrected by the laboratory. The copper result for sample T3-2 (253 ppm) was corrected to 244 ppm and the mercury result for T16-4 (.052 ppm) was corrected to 0.07 ppm.

Two sets of field duplicate samples were compared as a measure of overall precision. The relative percent differences (RPDs) between results for T2-6 and T2-60 were all less than 20 percent for less than the CRQL. The RPDs for T3-2 and T3-20 were also less than 20 percent except for the coarse fragment analysis (69 percent RPD). The high RPD for the percent coarse fragment analysis was probably caused by the inclusion of one or two large, heavy particles in one sample that were not present in the duplicate.

Other QA parameters tested were within control limits established in the project QA plan.

JG:kjr

to: Project File 55-1643-03(0241A)

from: James Good, Quality Assurance Officer March 6, 1989

re: QA Review: ASARCO RI, Phase II Marine Sediment Laboratory Results; EP Toxicity Metals

This QA review includes the following marine sediment samples analyzed by ASARCO for metals according to the Extraction Procedure Toxicity methods:

ASARCO I.D.	Parametrix I.D.	Date Sampled	Date Analyzed
88-4301	T16-4	06-30-88	08-05-88
88-4609	T16-1	07-06-88	08-05-88
88-4610	T12-1	07-06-88	08-05-88
88-4611	T5-0	07-07-88	08-05-88
88-4612	T18-2	07-07-88	08-05-88
88-4613	T10-1	07-07-88	08-05-88
88-4614	T10-2	07-07-88	08-05-88
88-4615	T11-7	07-07-88	08-05-88
88-4616	T8-4	07-08-88	08-05-88
88-4617	T6-3	07-08-88	08-05-88
88-4618	T6-1	07-08-88	08-05-88
88-4627	T4-2	07-12-88	08-05-88
88-4628	T3-2	07-12-88	08-05-88
88-4629	T3-20 Duplicate	07-12-88	08-05-88
88-4633	T22-1	07-13-88	08-05-88
88-4634	T22-2	07-13-88	08-05-88
88 <del>-4</del> 635	T4-4	07-13-88	08-05-88
88-4641	T3-6	07-14-88	08-05-88
88-4642	T3-5	07-14-88	08-05-88
88-4643	T3-4	07-14-88	08-05-88
88-4644	T2-5	07-14-88	08-05-88
88-4704	T2A-5	07-15-88	08-05-88
88-4705	T2-6	07-15-88	08-05-88
88-4706	T2-60 Duplicate	07-15-88	08-05-88
88-4894	T0-2	08-01-88	09-23-88
88-4895	T0-3	08-01-88	09-23-88
88-4896	T1-1	08-01-88	09-23-88
88-4897	T2-1	08-01-88	09-23-88

to: from: Project File

James Good, Quality Assurance Officer

55-1643-03(0241A) March 6, 1989

page 2

These marine sediment samples were collected between June 30 and August 1, 1988, and received by the laboratory one to four days following collection. The holding times between sample collection and analysis for mercury ranged from 29 to 36 days for samples T11-7, T5-0, T18-2, T10-1, T10-2, T16-1, T12-1, and T16-4. The holding times for mercury were 53 days for samples collected on August 1, 1988. The EP Tox mercury results for these samples will be flagged as estimates (J or N) because the 28-day holding time was exceeded.

The laboratory reported that samples T2A-5, T2-6, and T2-60 were warm when they arrived. EP Tox metals results for these samples will be flagged as estimates (J or N) due to inadequate sample preservation.

Other QA parameters tested were within control limits established in the project QA plan.

JG:kjr

to: Project File September 27, 1988
-----55-1643-03(0241a)
from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re:

MEMO # M-1

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix	Sample Date	Extraction Date	Analysis Date
1207988	MSO-10-1	10/27/87	11/02/87	11/04/87
1207989	MSO-10-2	10/27/87	11/02/87	11/04/87
1207990	MSO-10-3	10/27/87	11/02/87	11/04/87
1207991	MSO-10-4	10/27/87	11/02/87	11/04/87
1207992	MSO-9-6	10/27/87	11/02/87	11/05/87
1207993	MSO-9-7	10/27/87	11/02/87	11/05/87
1207994	MSO-9-8	10/27/87	11/02/87	11/05/87
1208003	Unspiked(SS-68)	10/27/87	11/02/87	11/03/87
1208004	M. Spike(SS-68)	10/27/87	11/02/87	11/03/87
1208005	M.S.Dup.(SS-68)	10/27/87	11/02/87	11/03/87
1208006	U.S.Dup.(SS-68)	10/27/87	11/02/87	11/03/87
1208007	METHOD BLANK	<del></del>	11/02/87	11/03/87

These marine sediment samples were collected on 10/27/87 and extracted within the seven day holding time limit (6 days) and analyzed within the 40 day limit (9 days). All the above samples were analyzed at a dilution of 30:1

Analysis of laboratory QA samples (1208003-1208006) could not resolve Benzo(b) and Benzo(k)fluoranthene so the combined results were reported as Benzo(b)fluoranthene.

The percent recovery of 4-Chloro-3-methylphenol in the matrix spike sample and the RPD (compared to the duplicate) exceeded the QC limits as did the percent recovery of pyrene in the spike and the duplicate samples. The matrix spike duplicate sample showed concentrations 17 percent higher on average than the matrix spike sample but no additional compounds were observed. No qualifications are required of the data from the other samples since the matrix spike and duplicate data is only designed for long-term evaluation of the precision and accuracy of the analysis.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

#### LLI# 1207988 (MSO-10-1)

This sample was analyzed 13 hours after the GC/MS Tuning and Mass Calibration was performed while the QA limit is 12 hours. However, since the initial and subsequent calibrations met all QA specifications no qualification action is deemed necessary.

The analysis was unable to resolve Benzo(b) and Benzo(k)fluoranthene so the combined results were reported as Benzo(b)fluoranthene.

A duplicate moisture analysis was performed on this sample and the resulting RPD was approximately 13 percent which was within the QC limit of 20 percent. An average of the two runs was reported.

#### LLI# 1207989 (MSO-10-2)

The internal standard area from chrysene and naphthalene were below the lower limits calculated from the 12-hour standard and the area for Perylene was close to the lower limit. This requires that the following compounds, which are associated with chrysene and naphthalene be qualified as undetected estimate (N):

Pyrene Butylbenzyl Phthalate 3,3'-Dichlorobenzidine Benzo(a)anthracene

bis(2-ethylhexyl) Phthalate Chrysene Nitrobenzene Isophorone

2-Nitrophenol 2,4-Dimethylphenol

Benzoic Acid bis(2-Chloroethoxy)methane 2,4-Dichlorophenol 1,2,4-Trichlorobenzene

Naphthalene 4-Chloroaniline

Hexachlorobutadiene 4-Chloro-3-methylphenol

2-Methylnaphthalene Nitrobenzene

The percent surrogate recovery of 2-fluorophenol (17%) was below the allowable QC limits of 25-121 percent.

In view of the above deficiencies and the fact that the sample was analyzed 2 hours after the 12 hour QA limit on the GC/MS Tuning and Mass Calibration, all the results of this sample will be qualified as estimated detection limits (N).

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

#### LLI# 1207990 (MSO-10-3)

All the internal laboratory QA parameters tested were within the limits established in the project QA plan except where specifically noted above.

## LLI# 1207991 (MSO-10-4)

This sample had higher than usual detection limits due to sample matrix or interferences observed in the GC/MS analysis but the detection limits were still within the Contract Required Detection Limits (CRDL).

All the internal laboratory QA parameters tested were within the limits established in the project QA plan except where specifically noted above.

#### LLI# 1207992 (MSO-9-6)

All the internal laboratory QA parameters tested were within the limits established in the project QA plan except where specifically noted above.

#### LLI# 1207993 (MSO-9-7)

All the internal laboratory QA parameters tested were within the limits established in the project QA plan except where specifically noted above.

#### LLI# 1207994 (MSO-9-8)

All the internal laboratory QA parameters tested were within the limits established in the project QA plan except where specifically noted above.

# LLI# 1208004 Matrix Spike(SS-68)

The percent surrogate recovery of Terphenyl-d14 exceeded the 137 percent control limits. Since only one surrogate did not meet the QA limits and the recovery was greater than 10% no corrective action was required.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 4

# LLI# 1208007 Method Blank

The Method Blank had 19 unknown or tentatively identified compounds some of which were detected in relatively high concentrations (100, 54, 30, 22, and 15 mg/l). However, the other samples did not seem to have a similar problem either in the number or concentration of unknown or tentatively identified compounds and no target compounds were detected so no qualitative action is deemed necessary.

to: Project File September 27, 1988 55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re: MEMO # M-2

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

LancasterI.D. #_	Parametrix	Sample Date	Extraction Date	Analysis Date
1208630	MSO-9-1	10/28/87	11/03/87	11/14/87
1208631	MSO-9-2	10/28/87	11/03/87	11/14/87
1208632	MSO-11-2	10/28/87	11/03/87	11/14/87
1208633	MSO-11-3	10/28/87	11/03/87	11/14/87
1208634	MSO-11-9	10/28/87	11/03/87	11/14/87
1208635	MSO-11-8	10/28/87	11/03/87	11/14/87
1208636	MSO-11-7	10/28/87	11/03/87	11/14/87
1208637	MSO-11-6	10/28/87	11/03/87	11/14/87
1208626	Unspiked(SS-60)	10/28/87	11/03/87	11/14/87
1208627	M. Spike(SS-60)	10/28/87	11/03/87	11/14/87
1208628	M.S.Dup.(SS-60)	10/28/87	11/03/87	11/14/87
1208629	U.S.Dup.(SS-60)	10/28/87	11/03/87	11/14/87
1208638	METHOD BLÁNK	* *	11/03/87	11/14/87

These marine sediment samples were collected on 10/28/87 and extracted within the seven day holding time limit (6 days) and analyzed within the 40 day QC limit (17 days).

Internal laboratory QA samples (120826-120829) were run at a dilution factor of 20 because of matrix interference in the non-diluted sample analysis. The method blank analysis showed no matrix interferences so a dilution run was not performed.

The surrogate recovery of 2,4,6-Tribromophenol in the matrix spike duplicate sample (LLI# 1208628) was 6% above the 122% QC upper limit. The QA/QC procedures allow one surrogate to exceed the limits before corrective action is required unless that recovery is below 10 percent which was not the case in this instance. In addition, the matrix spike analysis is primarily intended to indicate the long-term precision and accuracy of the analyses therefore, no qualifications are added to the data.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

The samples were analyzed first at a dilution of 20 and then re-injected as non-diluted samples. The reported results are from the non-diluted analysis. The sample used for the matrix spike and matrix spike duplicate medium (LLI# 1208626) was a surficial soils sample that was run at a dilution of 20 therefore, the values are not directly applicable to the undiluted analysis of the marine sediment samples in this batch because of a matrix effect.

### LLI# 1208630 (MSO-9-1)

This sample was analyzed at a dilution of 20 and re-injected straight which are the results reported. Benzo(b) and Benzo(k)flouranthene could not be resolved so the results reported is the combined total of the both isomers.

All other QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

# LLI# 1208631 (MSO-9-2)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

## LLI# 1208632 (MSO-11-2)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1208633 (MSO-11-3)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1208634 (MSO-11-9)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

#### LLI# 1208635 (MSO-11-8)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

### LLI# 1208636 (MSO-11-7)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

# LLI# 1208637 (MSO-11-6)

All QA parameters for this sample were within the limits established in the project QA plan except for those general problems described above.

#### LLI# 1208626 (SS-60)

Unusually high detection limits were due to sample matrix or interference problems. A dilution factor of 1 and 20 were run, while the DF 20 values were reported.

to: Project File

September 27, 1988

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

Revised: March 2, 1989

re:

**MEMO # M-3** 

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix	Sample Date	Extraction Date	Analysis Date
1209007	MSO-11-5	10/29/87	11/4/87	11/12/87
1209008	MSO-11-4	10/29/87	11/4/87	11/12/87
1209009	MSO-9-3	10/29/87	11/4/87	11/12/87
1209010	MSO-9-4	10/29/87	11/4/87	11/12/87
1209011	MSO-9-5	10/29/87	11/4/87	11/12/87
1209012	MSO-13-8	10/29/87	11/4/87	11/16/87
1209013	MSO-13-7	10/29/87	11/4/87	11/16/87
1209014	MSO-7-7	10/29/87	11/4/87	11/12/87
1209015	M.Spike(MSO-7-7)	10/29/87	11/4/87	11/12/87
1209016	M.S.Dup.(MSO-7-7)		11/4/87	11/12/87
1209017	U.S.Dup.(MSO-7-7)	10/29/87	11/4/87	11/12/87
1209018	REP-1 (MSO-9-5)	10/29/87	11/4/87	11/17/87
1209019	METHOD BLANK		11/4/87	11/12/87

These marine sediment samples were collected on 10/29/87 and extracted within the seven day QC holding time limit (6 days) and analyzed within the 40 day limit (18 days)

The detection limit for 2,4,5-trichlorophenol was higher than that specified in the QA plan for all samples listed above therefore, it will be qualified as estimated detection limits (N).

Analysis of the method blank indicated the presence of trace levels of diethylphthalate 0.2 mg/kg. Even though this was below the detection limit of 0.33 mg/kg it raises some questions about the validity of analysis for this compound in the samples listed above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

No qualifications were made to the data from samples where diethylphthalate was not detected while (J) (estimated concentrations) is used in those samples where it was detected at levels below 1.0 mg/kg (5 times the blank concentration).

The percent recovery and the relative percent difference (RPD) between the matrix spike and the matrix spike duplicate were within the QA limits for all eleven spike compounds.

All other QA parameters were within the limits established in the project QA plan except where specifically noted below.

#### LLI# 1209007 (MSO-11-5)

The quantitaion report for this sample was incorrect for tribromophenol due to a problem with the automatic integration system. The laboratory sent a revised quantitation report with the integration of tribromophenol manually calculated.

All other QA parameters for this sample were within the limits established in the project QA plan.

#### LLI# 1209008 (MSO-11-4)

All other QA parameters for this sample were within the limits established in the project QA plan.

#### LLI# 1209009 (MSO-9-3)

Semi-volatile internal standard area summaries for 1,4-dichlorobenzene-d4 and naphthalene-d8 were outside the 12 hour standard QA limits. Therefore the following compounds will be qualified as estimated detection limits (N) for this sample:

Phenol

2-Chlorophenol

1,4-Dichlorobenzene

1,2-Dichlorobenzene

bis(2-Chloroisopropyl)ether

N-nitroso-Di-n-propylamine

Nitrobenzene

2-Nitrophenol

Benzoic Acid

bis(2-Chloroethyl)ether -

1.3-Dichlorobenzene

Benzyl Alcohol

2-Methylphenol

4-Methylphenol

Hexachloroethane

Isophorone

2,4-Dimethylphenol

bis(2-Chloroethoxy)methane

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

2,4-Dichlorophenol Naphthalene Hexachlorobutadiene 2-Methylnaphthalene 1,2,4-Trichlorobenzene

4-Chloroaniline

4-Chloro-3-methylphenol

# LLI# 1209010 (MSO-9-4)

There is a discrepancy between the moisture content listed in the summary sheets (28.4%) and the one on the laboratory worksheet (28.8%). This was merely a transcription error and does not affect the analysis results.

#### LLI# 1209011 (MSO-9-5)

All other QA parameters for this sample were within the limits established in the project QA plan.

### LLI# 1209012 (MSO-13-8)

No information was presented by the lab concerning the semi-volatile internal standard area comparisons with the 12 hour standards for this sample. The information has been requested from the laboratory.

All other QA parameters for this sample were within the limits established in the project QA plan.

#### LLI# 1209013 (MSO-13-7)

No information was presented by the lab in the original data package concerning the semi-volatile internal standard area comparisons with the 12 hour standards for this sample. The laboratory explained that a computer error caused the form 8 for this sample not to be created and they sent a manually generated form.

All other QA parameters for this sample were within the limits established in the project QA plan.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 4

#### LLI# 1209014 (MSO-7-7)

Analysis of the method blank indicated the presence of 0.2 mg/kg of diethylphthalate which was also found in this sample at a level of 0.49 mg/kg. Since the sample concentration is less than 5 times that of the blank the data will be flagged as an estimate (J).

Semi-volatile organics surrogate recovery of phenol-d5 was 144% while the QA limits are 24 - 113 percent. Since only one surrogate was below the QA limits and the recovery was greater than 10 percent so no data qualifications are required. The Internal Standard Area for 1,4-dichlorobenzene was more than 50% below the internal standard area (the lower QA limit) so the following compounds will be qualified as estimated detection limits (N):

Phenol
2-Chlorophenol
1,4-Dichlorobenzene
1,2-Dichlorobenzene
bis(2-Chloroisopropyl)ether
N-nitroso-Di-n-propylamine

bis(2-Chloroethyl)ether 1,3-Dichlorobenzene Benzyl Alcohol 2-Methylphenol 4-Methylphenol Hexachloroethane

All other QA parameters for this sample were within the limits established in the project QA plan.

## LLI# 1209018 (REP-1, MSO-9-5)

There was no dry weight results sheet in the data package for this sample so one was requested from the lab. REP-1 is the field duplicate of MSO-9-5. Since no compounds were detected above the detection limits in either sample the RPD could not be determined.

The percent surrogate recovery of 2,4,6-tribromophenol was 165% while the QA limits were 19 - 122 percent. Since only one surrogate was above the QA limits and the recovery was greater than 10 percent so no data qualifications are required.

All other QA parameters for this sample were within the limits established in the project QA plan.

to:

Project File

September 27, 1988

from:

Bob Sullivan, Quality Assurance Officer

55-1643-03(0241a) Revised: March 2, 1989

те:

MEMO # M-4

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

LancasterI.D. #_	Parametrix I.D. #	Sample Date	Extraction Date	Analysis Date
1210560	MSO-13-6	11/3/87	11/9/87	11/26/87
1210561	MSO-13-5	11/3/87	11/9/87	11/26/87
1210562	MSO-13-4	11/3/87	11/9/87	11/26/87
1210563	MSO-13-3	11/3/87	11/9/87	11/26/87
1210564	MSO-13-2	11/3/87	11/9/87	11/26/87
<b>US DAY 313</b>	Unspiked		11/9/87	11/25/87
MS DAY 313	M. Špike		11/9/87	11/25/87
MSD DAY 313	M.S.Dup.		11/9/87	11/25/87
MB DAY 313	Method Blan	nk	11/9/87	11/25/87

These marine sediment samples were collected on 11/3/87 and extracted within the seven day limit (11/9/87) and analyzed within the 40 day limit (11/25/87).

The percent recovery and the relative percent difference (RPD) between the matrix spike and matrix spike duplicate samples fell within the QC limits for all eleven spike compounds.

All laboratory QA parameters tested were within the limits established in the project QA plan. Therefore no qualifiers are necessary for these data.

to: Project File

May 18, 1988 Revised September 26, 1988

55-1643-03(0241A)

from: James Good, Quality Assurance Officer

re: MEMORANDUM M5 QA Review: ASARCO RI, Marine Sediment Laboratory

Results; Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1210621	MSO-14-5	11-04-87	11-09-87	12-01-87
1210622	MSO-14-4	11-04-87	11-09-87	12-01-87
1210623	MSO-15-5	11-04-87	11-09-87	12-01-87
1210624	MSO-15-4	11-04-87	11-09-87	12-01-87
1210625	MSO-12-5	11-04-87	11-09-87	12-01-87
1210626	MSO-12-4	11-04-87	11-09-87	12-01-87
1210627	MSO-10-0	11-04-87	11-09-87	12-01-87
1210628	MSO-11-1	11-04-87	11-09-87	12-04-87
1210594	Unspiked Soil	11-04-87	11-13-87	12-01-87
1210595	Matrix Spike		11-13-87	12-01-87
1210596	Matrix Spike Duplicate		11-13-87	12-01-87
1210597	Method Blank		11-13-87	11-30-87

These marine sediment samples were collected on November 4, 1987 and received by the laboratory on November 6, 1987. Holding times for sample extraction and analysis met control limits established in the project QA plan.

# LLI #1210621 (MSO-14-5)

The moisture content reported by the laboratory is the average moisture content of two aliquots of sample MSO-14-5. The RPD between moisture content analyses was one percent.

to: Project File

from: James Good, Quality Assurance Officer

May 18, 1988

Revised September 30, 1988

Page 2

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high relative percent difference (RPD) between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Internal laboratory QA results indicated that other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210622 (MSO-14-4)

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210623 (MSO-15-5)

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210624 (MSO-15-4)

Matrix spiked duplicate recovery of pyrene was well above the QA limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

The semi-volatile internal standard area for perylene-d12 exceeded the upper QC limit. The laboratory reported that, in the analyst's judgement, the data is valid because surrogate standards were within specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds.

to: Project File

from: James Good, Quality Assurance Officer

May 18, 1988

Revised September 30, 1988

Page 3

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210625 (MSO-12-5)

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

The semi-volatile internal standard area for perylene-d12 exceeded the upper QC limit. The laboratory reported that, in the analyst's judgement, the data is valid because surrogate standards were within specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210626 (MSO-12-4)

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

The semi-volatile internal standard area for perylene-d12 exceeded the upper QC limit. The laboratory reported that, in the analyst's judgement, the data is valid because surrogate standards were within specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210627 (MSO-10-0)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total concentration of both isomers.

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate

to: Project File

from: James Good, Quality Assurance Officer

May 18, 1988

Revised September 30, 1988

Page 4

results for pyrene. Pyrene was detected in the sample and this result will be flagged as an estimate (J).

Other QA parameters tested were within control limits established in the project QA plan.

#### LLI #1210628 (MSO-11-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total concentration of both isomers.

Matrix spiked duplicate recovery of pyrene was well above the QC limit. This high recovery resulted in a high RPD between the matrix spiked and matrix spiked duplicate results for pyrene. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1210597 (Method Blank)

The laboratory included the wrong Matrix Spiked Duplicate Analysis Form in the data package. MS duplicate recovery of pyrene exceeded the upper QC limit and the RPD between matrix spiked and duplicate matrix spiked samples exceeded control limits for pyrene on the correct form. Pyrene was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify data.

All other laboratory QA parameters tested were within established limits and no organic compounds were detected in the method blank.

JG:kjr

Project File

September 27, 1988

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

Revised: March 2, 1989

ге:

to:

**MEMO # M-6** 

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

LancasterI.D. #_	Parametrix I.D. #	Sample Date	Extraction Date	Analysis Date
1211582	MSO-14-3	11/6/87	11/11/87	11/24/87
1211583	MSO-14-2	11/6/87	11/11/87	11/25/87
1211584	MSO-15-3	11/6/87	11/11/87	11/24/87
1211585	MSO-15-2	11/6/87	11/11/87	11/25/87
1211586	MSO-12-2	11/6/87	11/11/87	11/25/87
1211587	MSO-12-3	11/6/87	11/11/87	11/25/87
MS DAY 315	M. Spike	-00	11/11/87	11/23/87
MSD DAY 315	M.S.Dup.		11/11/87	11/23/87
MB DAY 315	Method Blank		11/11/87	11/23/87

These marine sediments were collected on 11/6/87 and extracted within the seven day QC holding time limits (5 days) and analyzed within the 40 day limit (19 days).

Two compounds (Di-n-butylphthalate, and Bis-2-ethylhexylphthalate) were detected in the method blank and the samples. Since approximately the same concentrations were observed in the samples as the blanks, the data for these compounds will be flagged as rejected (R) in all of the above samples.

Pentachlorophenol was handwritten on the matrix spike quantitation report (i.e., not identified by the computer), the data package did not include the spectra that this manual identification was based upon. However, since it was not detected in any of the samples listed above no qualification action is deemed necessary.

All the other internal laboratory QA parameters were within the limits established in the project QA/QC plan except where specifically noted below.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

#### LLI # 1211582 MSO-14-3

The internal standard area for 1,4-Dichlorobenzene-d4 was below the 12 hour standard limits for this sample. Therefore the following (undetected) compounds are qualified as estimated detection limits (N):

Phenol bis(2-Chloroethyl)ether
2-Chlorophenol 1,3-Dichlorobenzene
1,4-Dichlorobenzene Benzyl Alcohol
1,2-Dichlorobenzene 2-Methylphenol
bis(2-Chloroisopropyl)ether 4-Methylphenol
N-nitroso-Di-n-propylamine Hexachloroethane

All the other internal laboratory QA parameters were within the limits established in the project QA/QC plan for this sample.

#### LLI # 1211583 MSO-14-2

Surrogate recovery of Phenol-d5 was only 1 percent and the internal standard areas were outside the 12 hour standard limits for all 6 standards. These results dictated a reinjection of this sample for which all internal QA limits were met.

Although the standard areas of Chrysene-d12 and Perylene-d12 were not presented on the Standard Area Summary data sheet (Form VIII SV-I) they were located elsewhere in the data package. New data sheet has been requested from the Laboratory.

All the other internal laboratory QA parameters were within the limits established in the project QA/QC plan for this sample.

#### LLI # 1211584 MSO-15-3

All the internal laboratory QA parameters were within the limits established in the project QA/QC plan for this sample except where specifically noted above.

#### LLI # 1211585 MSO-15-2

This sample was re-injected since the 12 hour time limit had expired for the DFTPP calibration and the internal standard areas did not meet the QA specifications. The re-injected sample passed all QA parameters.

All the other internal laboratory QA parameters were within the limits established in the project QA/QC plan for this sample.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

## LLI # 1211586 MSO-12-2

All the internal laboratory QA parameters were within the limits established in the project QA/QC plan for this sample except where specifically noted above.

# LLI # 1211587 MSO-12-3

All the internal laboratory QA parameters were within the limits established in the project QA/QC plan for this sample except where specifically noted above.

Project File

September 27, 1988

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

Revised: March 2, 1989

re:

to:

**MEMO # M-7** 

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix I.D. #	Sample Date	Extraction Date	Analysis Date
1212031	MSO-8-2	11/9/87	11/12/87	11/24/87
1212037	Unspiked(SS-41)	11/9/87	11/17/87	11/23/87
1212038	Matrix Spike(SS-41)	11/9/87	11/17/87	11/23/87
1212039	M.Spike Dup.(SS-4)	1) 11/9/87	11/17/87	11/23/87
1212040	Method Blank		11/17/87	11/23/87

This marine sediment sample was collected on 11/9/87 and extracted within the seven day holding time limit (3 days) and analyzed within the 40 day limit (13 days).

All the internal laboratory QA parameters were within the specifications in the project QA/QC plan except where specifically noted below.

#### LLI#1212031 MSO-8-2

PCB analysis were run on this sample by mistake because it was run at the same time as a batch of surficial soils. No PCB's were detected.

The recovery of pyrene in the matrix spike was -347 percent and -18 percent in the matrix spike duplicate samples. Since the recoveries were low and pyrene was tentatively identified (below the detection limit) in the sample, pyrene will be qualified as an estimated detection limit (N).

to: Project File# 55-1643-03(0241a) from: Bob Sullivan, Quality Assurance Officer September 27, 1988 Page 2

LLI#1212037 Unspiked (SS-41) LLI#1212038 Matrix Spike (SS-41) LLI#1212039 Matrix Spike Duplicate (SS-41)

Due to saturation problems, the results for phenanthrene, fluoranthene, pyrene, benzo(a)anthrene, chrysene, and benzo(b)fluoranthene were reported from the samples run at a dilution of 10 while all other compound concentrations were taken from the undiluted sample run.

The recovery of pyrene in the matrix spike was -347 percent and -18 percent in the matrix spike duplicate samples. Since the recoveries were low and pyrene was tentatively identified (below the detection limit) in the sample, pyrene will be qualified as an estimated detection limit (N).

Project File September 27, 1988 55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

**MEMO # M-8** re: QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

to:

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix I.D. #	Sample Date	Extraction Date	Analysis Date
1212044	MSO-7-5	11/9/87	11/12/87	11/21/87
1212045	MSO-7-4	11/9/87	11/12/87	11/21/87
1212046	MSO-7-3	11/9/87	11/12/87	11/21/87
1212047	MSO-8-4	11/9/87	11/12/87	11/21/87
1212048	MSO-8-3	11/9/87	11/12/87	11/21/87
1212049	MSO-7-2	11/9/87	11/12/87	11/21/87
1212050	MSO-8-1	11/9/87	11/12/87	11/23/87
1212051	REP-2	11/9/87	11/12/87	11/18/87
1212041	Unspiked(MSO-7-6)	• •	11/12/87	11/18/87
1212042	M. Spike(MSO-7-6)	11/9/87	11/12/87	11/18/87
1212043	M.S.Dup.(MSO-7-6)		11/12/87	11/18/87
1212052	Method Blank		11/12/87	11/18/87

These marine sediment samples were collected on 11/9/87 and extracted within the seven day holding time limit (11/12/87) and analyzed within the 40 day limit (11/23/87).

The surrogate recovery of Acenaphthene exceeded the QC limit in the matrix spike sample which in turn resulted in the relative percent difference (RPD) between the spiked and spike duplicate samples to exceed the QC limits. The relative percent difference between the spiked sample and the duplicate spiked sample also exceeded the control limits for 4-Chloro-3-methylphenol, 1,2,4-Trichlorobenzene, and Pyrene. No action was taken since the Matrix Spike comparisons are to determine the long-term precision and accuracy of the analytical method on various matrices and these data alone cannot be used to evaluate the precision and accuracy of individual samples.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

The internal standard area summary sheet corresponding to this sample was not included in the data package. The necessary information was obtained from another data package and the summary sheet has been requested from the lab.

Other QA parameters tested were within limits established in the project QA plan.

## 1212044 (MSO-7-5)

QA parameters tested were within limits established in the project QA plan except where specifically noted above.

### 1212045 (MSO-7-4)

QA parameters tested were within limits established in the project QA plan except where specifically noted above.

#### 1212046 (MSO-7-3)

QA parameters tested were within limits established in the project QA plan except where specifically noted above.

#### 1212047 (MSO-8-4)

QA parameters tested were within limits established in the project QA plan except where specifically noted above.

#### 1212048 (MSO-8-3)

QA parameters tested were within limits established in the project QA plan except where specifically noted above.

#### 1212049 (MSO-7-2)

QA parameters tested were within limits established in the project QA plan except where specifically noted above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

# LLI# 1212050 (MSO-8-1)

This sample was re-injected because the chromatogram cut off too early in the initial run-

Other QA parameters tested were within limits established in the project QA plan.

# LLI# 1212051 (REP-2) (MSO-7-6)

REP-2 was a field replicate of MSO-7-6. No compounds were detected above the detection limits in either sample. Moisture analysis for the replicates showed a 7.9% RPD, which is within the 20% QA limit established for the project.

Other QA parameters tested were within limits established in the project QA plan.

to: Project File

September 27, 1988

Tojoct The

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

Revised: March 2, 1989

re:

MEMO # M-9

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data-

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix	Sample Date	Extraction Date	Analysis Date
1212247	MSO-7-1	11/10/87	11/13/87	11/19/87
1212248	MSO-6-4	11/10/87	11/13/87	11/19/87
1212249	MSO-6-3	11/10/87	11/13/87	11/19/87
1212250	MSO-6-1	11/10/87	11/13/87	11/19/87
1212251.	MSO-6-2	11/10/87	11/13/87	11/19/87
1212252	MSO-5-3	11/10/87	11/13/87	11/19/87
1212253	MSO-5-2	11/10/87	11/13/87	11/19/87
Day317-B	Unspiked		11/13/87	11/19/87
Day317-B	M. Špike		11/13/87	11/19/87
Day317-B	M.S.Dup.		11/13/87	11/19/87
Day317-B	U.S.Dup.		11/13/87	11/19/87
Day317-B	Method Bla	ank	11/13/87	11/19/87

These marine sediment samples were collected on 11/10/87 and extracted within the seven day QC holding time limit (3 days) and analyzed within the 40 day limit (9 days).

Benzoic acid was detected in the matrix spike and the matrix spike duplicate but not in the unspiked sample. No action was taken since it was not detected in any of the samples and the results of the spiked sample are used primarily for the evaluation of the long-term precision and accuracy of the analysis.

Butylbenzylphthalate was found in the method blank but not in any of the samples so no qualifying action is required.

The results of the other internal laboratory QA parameters tested were within the limits established in the project QA plan except where specifically noted below.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

### LLI# 1212247 (MSO-7-1)

There were problems with the internal standard area for chrysene and perylene and the percent surrogate recovery of Terphenyl-d14 in this sample so it was re-injected. The re-injected sample met all QA criteria.

The results of the other internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

### LLI# 1212248 (MSO-6-4)

The results of the internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

### LLI# 1212249 (MSO-6-3)

The results of the internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

#### LLI# 1212250 (MSO-6-1)

The results of the internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

#### LLI# 1212251 (MSO-6-2)

The results of the internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

#### LLI# 1212252 (MSO-5-3)

The results of the internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

to: Project File# 55-1643-03(0241a) from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

# LLI# 1212253 (MSO-5-2)

The results of the internal laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

to: Project File

May 23, 1988

Revised September 30, 1988 55-1643-03(0241A)

from: James Good, Quality Assurance Officer

re: MEMORANDUM M10 QA Review: ASARCO RI, Marine Sediment Laboratory

Results; Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1212569	MSO-17-1 Unspik	ed11-12-87	11-16-87	12-03-87
1212570	MSO-18-2	11-11-87	11-16-87	12-03-87
1212571	MSO-18-1	11-11-87	11-16-87	12-03-87
1212572	Rep. #3		11-16-87	12-04-87
1212573	MSO-17-3	11-12-87	11-16-87	12-04-87
1212574	MSO-17-2	11-12-87	11-16-87	12-04-87
1212575	MSO-16-2	11-12-87	11-16-87	12-04-87
1212576	MSO-16-1	11-12-87	11-16-87	12-04-87
1212577	MSO-16-4	11-12-87	11-16-87	12-04-87
1212578	MSO-16-3	11-12-87	11-16-87	12-04-87
1212579	MSO-17-4	11-12-87	11-16-87	12-04-87
1212582	Method Blank		11-16-87	12-03-87
1212580	Matrix Spike		11-16-87	12-03-87
1212581	Matrix Spike Duplicate	-	11-16-87	12-03-87

These marine sediment samples were collected on November 11 and 12, 1987 and received by the laboratory on November 13, 1987. Holding times for sample extraction and analysis met control limits specified in the project QA plan.

Matrix spiked and matrix spiked duplicate recoveries exceeded QC limits for 4-nitrophenol. This compound was not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify or reject sample results.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 23, 1988
Revised September 30, 1988
Page 2

## LLI #1212569 (MSO-17-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The results reported for benzo(b)fluoranthene are the total for both isomers.

Dilution factor two (DF2) results were reported for all compounds tested.

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for chrysene-d12 and perylene-d12. The laboratory sent a corrected form including manually calculated limits for chrysene-d12 and perylene-d12 that indicated the semi-volatile internal standard areas for these compounds were within QC limits for the dilution factor ten (DF10) analysis.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212570 (MSO-18-2)

The laboratory reported that the computer program did not properly retrieve the semi-volatile internal standard area limits for chrysene-d12 and perylene-d12 (DF10 analysis), and phenanthrene-d10, chrysene-d12, and perylene-d12 (DF1 analysis). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

Other QA parameters tested were within control limits established in the project QA plan

# LLI #1212571 (MSO-18-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The results reported for benzo(b)fluoranthene are the totals for both isomers.

The laboratory reported that the computer program did not properly retrieve the semi-volatile internal standard area limits for chrysene-d12 and perylene-d12 (DF10 analysis), and phenanthrene-d10, chrysene-d12, and perylene-d12 (DF1 analysis). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

from: James Good, Quality Assurance Officer

May 23, 1988

Revised September 30, 1988

Page 3

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212572 (Rep. #3)

Sample Rep 3 was a field duplicate of sample MSO-16-4. There were no semi-volatile target compounds detected in either sample and the RPD between moisture content results was three percent.

The laboratory reported that the computer program did not properly retrieve the semi-volatile internal standard area limits for chrysene-d12 and perylene-d12 (DF10 analysis), and phenanthrene-d10, chrysene-d12, and perylene-d12 (DF1 analysis). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212573 (MSO-17-3)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for chrysene-d12 and perylene-d12 (DF10 analysis), and phenanthrene-d10, chrysene-d12, and perylene-d12 (DF1 analysis). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212574 (MSO-17-2)

The laboratory reported that the computer program did not properly retrieve the semi-volatile internal standard area limits for chrysene-d12 and perylene-d12 (DF10 analysis), and phenanthrene-d10, chrysene-d12, and perylene-d12 (DF1 analysis). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 23, 1988
Revised September 30, 1988
Page 4

The GC/MS tuning frequency exceeded the 12-hour limit for the dilution factor-10 analysis of this sample. All instrument tuning ratios were well within control limits and no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

## LLI #1212575 (MSO-16-2)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for chrysene-d12 and perylene-d12 (DF10), and phenanthrene-d10, chrysene-d12, and perylene-d12(DF1). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

The GC/MS tuning frequency exceeded the 12-hour limit for the dilution factor-10 analysis of this sample. All instrument tuning ratios were well within control limits and no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

## LLI #1212576 (MSO-16-1)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for chrysene-d12 and perylene-d12 (DF10), and phenanthrene-d10, chrysene-d12, and perylene-d12 (DF1). The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits for the analyses of both dilutions.

The GC/MS tuning frequency exceeded the 12-hour limit for the dilution factor-10 analysis of this sample. All instrument tuning ratios were well within control limits and no action was taken to qualify data.

Other QA parameters tested were within control limits established in the project QA plan.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 23, 1988
Revised September 30, 1988
Page 5

# LLI #1212577 (MSO-16-4)

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212578 (MSO-16-3)

Surrogate recovery of 2-fluorophenol for the semi-volatile organics analysis was less than the lower QC limit of 25 percent. The sample was re-extracted and re-analysis indicated that low surrogate recovery was probably due to sample matrix interference. No qualification was placed on data because only one surrogate was out of specification and that surrogate had greater than 10 percent recovery.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212579 (MSO-17-4)

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1212582 (Method Blank)

The laboratory reported that the computer program did not properly retrieve the internal standard area limits for chrysene-d12 and perylene-d12. The laboratory sent corrected forms including manually calculated limits that indicated the internal standard areas for these compounds were within QC limits.

Other QA parameters tested were within control limits established in the project QA plan. No target organic compounds were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination of samples.

JG:kjr

to: Project File

September 27, 1988

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

Revised: March 2, 1989

re:

MEMO # M-11

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

LancasterI.D. #_	ParametrixI.D. #	Sample Date	Extraction Date	Analysis Date
1213233	MSO-19-2	11/12/87	11/18/87	12/08/88
1213234	MSO-19-1	11/12/87	11/18/87	12/08/88
1213235	MSO-20-1	11/12/87	11/18/87	12/08/88
1213236	MSO-20-2	11/12/87	11/18/87	12/08/88
1213237	MSO-18-3	11/12/87	11/18/87	12/08/88
1213238	MSO-4-3	11/12/87	11/18/87	12/08/88
<b>US DAY 322</b>	Unspiked		11/18/87	12/08/88
MS DAY 322	M. Ŝpike		11/18/87	12/08/88
MSD DAY 322			11/18/87	12/08/88
MB DAY 322	Method Blan	ık	11/18/87	12/08/88

These marine sediment samples were collected on 11/12/87 and extracted within the seven day holding time (6 days) and analyzed within the 40 day QC limit (26 days).

The internal laboratory QA results showed that the spike recovery of Phenol-d5 exceeded the QC limits of 90 percent. No action is required to qualify the data based on these results alone.

All other laboratory QA parameters tested were within established limits except were specifically noted below under each of the samples.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

## LLI # 1213233 MSQ-19-2

A duplicate moisture content analysis was performed on this sample which did not pass QA criteria of 20 percent RPD so a second duplicate was required to achieve a passing level of 6 percent.

All other laboratory QA parameters tested were within established limits for this sample.

# LLI # 1213234 MSO-19-1

The detected concentration of Phenanthrene was listed as 0.58 mg/kg while the detection threshold was 0.60 mg/kg. As a result, Phenanthrene will be considered undetected (<) at the 0.60 mg/kg level.

All other laboratory QA parameters tested were within established limits for this sample.

# LLI # 1213235 MSO-20-1

All other laboratory QA parameters tested were within established limits for this sample.

# LLI # 1213236 MSO-20-2

All other laboratory QA parameters tested were within established limits for this sample.

# LLI # 1213237 MSO-18-3

All other laboratory QA parameters tested were within established limits for this sample.

# LLI # 1213238 MSO-4-3

All other laboratory QA parameters tested were within established limits for this sample.

to: Project File

September 27, 1988

55-1643-03(0241a)

from:

Bob Sullivan, Quality Assurance Officer

re:

MEMO # M-12

QA review: ASARCO RI/FS, Marine Sediments Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster	Parametrix	Sample Date	Extraction Date	Analysis Date
1214771	MSO-2-3	11/18/87	11/23/87	12/05/87
1214772	MSO-3-3	11/18/87	12/08/87	12/11/87
1214773	MSO-3-2	11/18/87	11/23/87	12/05/87
1214774	MSO-3-1	11/18/87	11/23/87	12/05/87
1214775	MSO-4-0	11/18/87	11/23/87	12/05/87
1214776	MSO-4-2	11/18/87	11/23/87	12/05/87
1214477	MSO-13-1	11/17/87	11/23/87	12/05/87
1214478	MSO-12-1	11/17/87	11/23/87	12/05/87
<b>US DAY 327</b>	Unspiked	<b></b>	11/23/87	12/02/87
<b>MS DAY 327</b>	M. Špike	•••	11/23/87	12/02/87
MSD DAY 327			11/23/87	12/02/87
MB DAY 327	Method Blan	k	11/23/87	12/02/87

These marine sediment samples were collected on 11/17 and 11/18/87 and extracted for the most part within the seven day holding time limit. The exception is MSO-3-3 (LLI# 1214772) which had two phases in the original extraction and had to be re-extracted. This re-extraction occurred 20 days after the sample date. The qualifications to this data is listed below under the specific sample.

The percent recovery of Phenol and 2,4-Dinitrotoluene exceeded the spike recovery QA limits in the matrix spike and the matrix spike duplicate samples. No corrective action has been taken unless other QA criteria are not satisfied.

All the other laboratory QA parameters tested were within the limits established in the project QA plan, except where specifically noted below.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 2

## LLI# 1214771 (MSO-2-3)

A duplicate analysis of the moisture content in this sample showed a relative percent difference of 5 percent which is within the QC limit of 20 percent. The internal standard area of Phenanthrene-d10 was less than 50 percent of the 12 hour standard area which is the established QA limit. Therefore the following compounds are qualified as estimated detection limits (N):

Fluoranthene 4-Bromophenyl Phenyl Ether Pentachlorophenol Anthracene N-nitrosodiphenylamine Hexachlorobenzene Phenanthrene Di-n-butyl Phthalate

All the other laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

## LLI# 1214772 (MSO-3-3)

This sample was re-extracted and re-injected because two phases were present in the initial extraction. As a result the matrix spike and the Matrix Spike Duplicate samples were different than the other samples covered in this memo. The percent spike recovery of Phenol in the Matrix Spike Duplicate sample exceeded the upper QA limit.

The re-extraction occurred 20 days after the sampling date and as a result the QC holding time limit of seven days was grossly exceeded. Therefore, none of the sample results are acceptable and will be flagged as estimates (N or J) since none of the target compounds were detected.

#### LLI# 1214773 (MSO-3-2)

The percent surrogate recovery of Phenol-d5 was 126 percent while the QA limits are 24 - 113 percent. Since Phenol was the only surrogate that did not meet the QA limits and the recovery was greater than 10 percent, no corrective action is required.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 3

The Internal Standard area for Phenanthrene-d10 exceeded the upper limit of the 12 hour standard area. Therefore the following compounds are qualified as estimated detection limits (N):

Fluoranthene

4-Bromophenyl Phenyl Ether

Pentachlorophenol

Anthracene

N-nitrosodiphenylamine

Hexachlorobenzene

Phenanthrene

Di-n-butyl Phthalate

All the other laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

## LLI# 1214774 (MSO-3-1)

The Internal Standard area for Naphthalene-d8 and Acenaphthene-d10 exceeded the upper limit of the 12 hour standard area. Since Diethyl Phthalate was the only compound detected it will be qualified as an estimate (J) while the following compounds are qualified as (N) because they were undetected:

Fluorene

2-Nitrophenol

Benzoic Acid

2,4-Dichlorophenol

Naphthalene

Hexachlorobutadiene

2-Methylnaphthalene

Hexachlorocyclopentadiene

2,4,5-Trichlorophenol

2-Nitroanaline Acenaphthylene

Acenaphthene

4-Nitrophenol

2,4-Dinitrotoluene

4-Chlorophenylphenyl ether

Isophorone

2,4-Dimethylphenol

bis(2-Chloroethoxy)methane

1,2,4-Trichlorobenzene

4-Chloroaniline

4-Chloro-3-methylphenol

Nitrobenzene

2.4.6-Trichlorophenol

2-Chloronaphthalene

Dimethyl Phthalate

3-Nitroanaline

2,4-Dinitrophenol

Dibenzofuran

2.6-Dinitrotoluene

4-Nitroaniline

All the other laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 4

## LLI# 1214775 (MSO-4-0)

The Internal Standard area for Naphthalene-d8, 1,4-Dichlorobenzene-d4 and Phenanthrene-d10 exceeded the upper limit of the 12 hour standard area. Therefore the following compounds are qualified as estimated detection limits (N):

Nitrobenzene

2-Nitrophenol Benzoic Acid

2,4-Dichlorophenol

Naphthalene

Hexachlorobutadiene 2-Methylnaphthalene

Phenol 2-Chlorophenol

1,4-Dichlorobenzene
1,2-Dichlorobenzene

bis(2-Chloroisopropyl)ether N-nitroso-Di-n-propylamine bis(2-Ethylhexyl)Phthalate

4-Bromophenyl Phenyl Ether

Pentachlorophenol

Isophorone

2,4-Dimethylphenol

bis(2-Chloroethoxy)methane

1.2.4-Trichlorobenzene

4-Chloroaniline

4-Chloro-3-methylphenol Di-n-butyl Phthalate

bis(2-Chloroethyl)ether 1,3-Dichlorobenzene Benzyl Alcohol

2-Methylphenol 4-Methylphenol

Hexachloroethane N-nitrosodiphenylamine

Hexachlorobenzene

For the same reason the following compounds will be qualified as (J) since they were detected in the sample.

Phenanthrene

Anthracene

Fluoranthene Benzo(a)Anthracene Pyrene Chrysene

Benzo(b)fluoranthene

Benzo(a)pyrene

All the other laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

#### LLI# 1214776 (MSO-4-2)

The Internal Standard area for Naphthalene-d8, Acenaphthene-d10 and Phenanthrene-d10 exceeded the upper limit of the 12 hour standard area and the sample was analyzed after the 12 hour calibration period. Therefore all the target compounds are qualified as estimated detection limits (N).

from: Bob Sullivan, Quality Assurance Officer

September 27, 1988

Page 5

## LLI# 1214477 (MSO-13-1)

The surrogate recovery of Terphenyl-d14 exceeded the QA limit of 137 percent (142%). Since Terphenyl was the only surrogate that exceeded the limits and the recovery was greater than 10 percent, no corrective action is required.

All the other laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

#### LLI# 1214478 (MSO-12-1)

The surrogate recovery of Terphenyl-d14 exceeded the QA limit of 137 percent (138%). Since Terphenyl was the only surrogate that exceeded the limits and the recovery was greater than 10 percent, no corrective action is required.

All the other laboratory QA parameters tested were within the limits established in the project QA plan for this sample except where specifically noted above.

to: Project File

May 9, 1988 Revised September 30, 1988

55-1643-03(0241A)

from: James Good, Quality Assurance Officer

re: MEMORANDUM M13 QA Review: ASARCO RI, Marine Sediment Laboratory Results; Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1215190	MSO-4-1	11-19-87	11-24-87	12-08-87
1215191	MSO-5-1	11-19-87	11-24-87	12-08-87
1215192	MSO-5-0	11-19-87	11-24-87	12-08-87
1215193	Rep. 4 Soil Sampl	e 11-19-87	11-24-87	12-08-87
328	Unspiked Soil	••	11-24-87	12-08-87
328	Matrix Spike	•-	11-24-87	12-08-87
328	Matrix Spike		11-24-87	12-08-87
	Duplicate			
328	Method Blank		11-24-87	12-08-87

Matrix spiked recoveries of phenol, 4-chloro-3-methylphenol, and 2,4-dinitrotoluene exceeded QC limits for recovery of these compounds. Matrix spiked duplicate recoveries exceeded control limits for 2-chlorophenol, phenol, 4-chloro-3-methylphenol, 4-nitrophenol, and 2,4-dinitrotoluene. These compounds were not detected in the sample and other MS/MSD results were within control limits, thus no action was taken to qualify or reject sample results.

The moisture content results reported by the laboratory for sample 1215193 is the average moisture content of two aliquots of the sample.

# Field Replicate Analysis

Sample 1215193 was a field replicate of sample 1215190(MSD-4-1). No target compounds were detected in either sample and the laboratory reported the same detection limits in the sample and replicate sample for all compounds analyzed.

to: Project File from: James Good, Quality Assurance Officer May 9, 1988 Revised September 30, 1988 Page 2

Internal laboratory QA results indicated that all QA parameters tested were within control limits established in the project QA plan.

JG:kjr

to: Project File

May 24, 1988

Revised September 30, 1988 55-1643-03(0241A)

from: James Good, Quality Assurance Officer

re: MEMORANDUM M14 QA Review: ASARCO RI, Marine Sediment Laboratory

Results; Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1215591	MSO-21-1	11-20-87	11-25-87	12-08-87
1215592	MSO-21-2	11-20-87	11-25-87	12-08-87
1215593	MSO-21-3	11-20-87	11-25-87	12-08-87
1215594	MSO-14-1	11-20-87	11-25-87	12-09-87
1215595	MSO-6-0 (unspiked)	11-20-87	11-25-87	12-08-87
1215598	Method Blank	••	11-25-87	12-08-87
1215596	Matrix Spike	<b></b>	11-25-87	12-08-87
1215597	Matrix Spike Duplicate		11-25-87	12-08-87

These marine sediment samples were collected on November 20, 1987 and received by the laboratory on November 24, 1987. Holding times for sample extraction and analysis met control limits specified in the project QA plan.

Matrix spiked recoveries exceeded QC limits for phenol, 4-chloro-3-methylphenol, pentachlorophenol, and 2,4-dinitrotoluene. The relative percent difference (RPD) between the spiked result and the duplicate spiked result was twice the 33 percent QC limit for 4-chloro-3-methylphenol. These compounds were not detected in the samples and other MS/MSO results were within control limits, thus no action was taken to qualify or reject sample data.

from: James Good, Quality Assurance Officer

May 24, 1988

Revised September 30, 1988

Page 2

# LLI #1215591 (MSO-21-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total concentration of both isomers.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1215592 (MSO-21-2)

Semi-volatile internal standard area exceeded the upper QC limit for chrysene-d12. However, the laboratory reported that the analyst judged the data to be valid because surrogate standards were in specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds. Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1215593 (MSO-21-3)

Semi-volatile internal standard area exceeded the upper QC limit for chrysene-d12. However, the laboratory reported that the analyst judged the data to be valid because surrogate standards were in specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1215594 (MSO-14-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The result reported for benzo(b)fluoranthene is the total for both isomers.

Semi-volatile internal standard areas exceeded the QC limits for naphthalene-d8 and chrysene-d12. However, the laboratory reported that the analyst judged the data to be valid because surrogate standards were in specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 24, 1988
Revised September 30, 1988
Page 3

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1215595 (MSO-6-0)

Other QA parameters tested were within limits established in the project QA plan.

## LLI #1215598 Method Blank

No target organic compounds were detected in the method blank indicating laboratory sample analysis procedures did not introduce significant contamination of samples.

JG:kjr

to: Project File

May 24, 1988 Revised September 30, 1988 55-1643-03(0241A)

from: James Good, Quality Assurance Officer

re: MEMORANDUM M15 QA Review: ASARCO RI, Marine Sediment Laboratory Results, Organic Compounds

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc.:

LLI I.D.	Parametrix I.D.	Sample Date	Extraction Date	Analysis Date
1216900	MSO-22-1	11-25-87	12-02-87	12-09-87
1216901	MSO-22-2	11-25-87	12-02-87	12-10-87
1216902	MSO-22-3	11-25-87	12-02-87	12-10-87
1216903	MSO-2-1	11-25-87	12-02-87	12-10-87
1216904	MSO-2-2	11-25-87	12-02-87	12-10-87
1216905	MSO-0-1	11-25-87	12-02-87	12-10-87
1216906	MSO-0-2	11-25-87	12-02-87	12-10-87
1216907	MSO-0-3	11-25-87	12-02-87	12-10-87
1216908	MSO-1-1	11-25-87	12-02-87	12-10-87
336	Unspiked Soil			12-09-87
336	Matrix Spike	••	12-02-87	12-09-87
336	Matrix Spike Duplicate		12-02-87	12-09-87
336	Method Blank		12-02-87	12-09-87

These marine sediment samples were collected on November 25, 1987 an received by the laboratory on December 1, 1987. Holding times for sample extraction and analysis met control limits specified in the project QA plan.

## LLI #1216900 (MSO-22-1)

The laboratory reported that the isomers benzo(b)fluoranthene and benzo(k)fluoranthene were not resolved under the sample analysis conditions. The results reported for benzo(b)fluoranthene are the total for both isomers.

from: James Good, Quality Assurance Officer

May 24, 1988

Revised September 30, 1988

Page 2

Semi-volatile internal standard areas were reported to be zero for chrysene-d12 and perylene-d12.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1216901 (MSO-22-2)

Internal laboratory QA results indicated that all laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1216902 (MSO-22-3)

Internal laboratory QA results indicated that all laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1216903 (MSO-2-1)

Internal laboratory QA results indicated that all laboratory QA parameters tested were within limits established in the project QA plan.

# LLI #1216904 (MSO-2-2)

Semi-volatile internal standard areas were less than the lower QC limits for 1,4-dichlorobenzene-d4, naphthalene-d8, acenaphthene-d10, phenanthrene-d10, chrysene-d12, and perylene-d12. Following re-injection and re-analysis of the sample, all semi-volatile internal standard areas were within QC limits.

Other QA parameters tested were within control limits established in the project QA plan.

# LLI #1216905 (MSQ-0-1)

The laboratory incorrectly labeled the sample as MSO-2-2 on the cover sheet and results pages in the QA package.

Internal laboratory QA results indicated that all laboratory QA parameters tested were within limits established in the project QA plan.

to: Project File (55-1643-03-0241A) from: James Good, Quality Assurance Officer May 24, 1988
Revised September 30, 1988
Page 3

# LLI #1216906 (MSO-0-2)

The semi-volatile internal standard area exceeded the upper QC limit for chrysene-d12. However, the laboratory reported that the analyst judged the data to be valid because surrogate standards were in specifications, there were no reportable hits for target compounds, and the increased sensitivity would have enhanced the identification of target compounds.

Other QA parameters tested were within control limits specified in the project QA plan.

# LLI #1216907 (MSO-0-3)

Internal laboratory QA results indicated that all laboratory QA parameters tested were within limits established in the project QA plan.

### LLI #1216908 (MSO-1-1)

Internal laboratory QA results indicated that all laboratory QA parameters tested were within limits established in the project QA plan.

JG:kjr

1.6.85

APPENDEX T

MARINE SEDIMENT CORES QUALITY ASSURANCE MEMORANDA

to:

Project File

55-1643-03(0241A)

from:

James Good, Quality Assurance Officer

February 21, 1989

re:

QA Review: ASARCO RI, Marine Sediment Core Laboratory Results;

Total Metals

This QA review includes the following marine sediment core samples analyzed by ASARCO for total metals:

ASARCO I.D.	Parametrix I.D.	Date Sampled	Date Analyzed
88-8386	10A-01	11-16-88	01-30-89
88-8388	10A-12	11-16-88	01-30-89
88-8390	10A-23	11-16-88	01-30-89
88-8392	10A-34	11-16-88	01-30-89
88-8394	10A-45	11-17-88	01-30-89
88-8396	10A-78	11-17-88	01-30-89
88-8761	10-01	11-30-88	01-30-89
88-8762	10-12	11-30-88	01-30-89
88-8763	10-23	11-30-88	01-30-89
88-8764	10-34	11-30-88	01-31-89
88-8765	10-45	11-30-88	01-30-89
88-8766	10-230 Duplicate	11-30-88	01-30-89
88-8767	10-1015	11-30-88	01-31-89
88-8768	T7-2-01	12-01-88	01-30-89
88-8769	T7-2-12	12-01-88	01-30-89
88-8770	T7-2-23	12-01-88	01-30-89
88-8771	T7-2-34	12-01-88	01-30-89
88-8772	T7-2-45	12-01-88	01-30-89
88-9121	T13-2.5-01	12-05-88	01-30-89
88-9122	T13-2.5-12	12-05-88	01-30-89
88-9123	T13-2.5-23	12-05-88	01-30-89
88-9124	T13-2.5-34	12-05-88	01-30-89
88-9125	T13-2.5-45	12-05-88	01-31-89
88-9126	T13-2.5-910	12-05-88	01-31-89
88-9127	T16-0-01	12-07-88	01-30-89
88-9128	T16-0-12	12-07-88	01-30-89
88-9129	T16-0-23	12-07-88	01-30-89
88-9130	T16-0-34	12-07-88	01-30-89
88-9131	T16-0-45	12-07-88	01-30-89

to: from: page 2	Project File James Good, Quality Assurance Officer		55-1643-03(0241A) February 21, 1989
88-9132	T16 0 1012	12-07-88	01-31-89
	T16-0-1012		
88-9188	7-2-910B	12-09-88	01-30-89
88-9189	7-2-1015	12-09-88	01-30-89
88-9225	2-01	12-13-88	01-30-89
88-9226	2-12	12-13-88	01-30-89
88-9227	2-23	12-13-88	01-30-89
88-9228	2-34	12-13-88	01-31-89
88-9229	2-45	12-13-88	01-30-89
88-9230	2-78	12-13-88	01-31-89
89-3	2-120 Duplicate	12-13-88	01-30-89

These marine sediment core samples were collected between November 16 and December 13, 1988, and generally received by the laboratory within six days following collection. Sample 2-120 Duplicate was received 23 days after sample collection. All total metals analyses were completed well within the six-month holding time limit.

The laboratory made an error in reading the 255 ppm zinc result from the calibration curve for sample T13-2.5-23. The correct result is 270 ppm total zinc.

The relative percent differences (RPDs) between results for field duplicate samples 10-23 and 10-230 were all less than 30 percent except the RPD for copper (50 percent). The RPDs between field duplicate results for samples 2-12 and 2-120 were all less than 25 percent except the coarse fragments RPD (56 percent). The amount of variability seen in these results was judged to be acceptable, especially since the samples were collected from separate cores.

Other QA parameters tested were within control limits and no action was taken to qualify sample data.

JG:kjr

to:

Project File

55-1643-03(0241A)

from:

James Good, Quality Assurance Officer

March 1, 1989

re:

QA Review: ASARCO RI, Marine Sediment Core Laboratory Results; EP

Tox Metals

This QA review includes the following marine sediment core samples analyzed by ASARCO for EP Toxicity metals and pH:

ASARCO I.D.	Parametrix I.D.	Date Sampled	Date Analyzed
88-8387	10A-01	11-16-88	02-01-89
88-8389	10A-12	11-16-88	02-01-89
88-8391	10A-23	11-16-88	02-01-89
88-8393	10A-34	11-16-88	02-01-89
88-8395	10A-45	11-17-88	02-01-89
88-8397	10A-78	11-17-88	02-01-89
88-8773	T7-2-01	12-01-88	02-01-89
88-8774	T7-2-12	12-01-88	02-01-89
88-8775	T7-2-23	12-01-88	02-01-89
88-8776	T7-2-34	12-01-88	02-01-89
88-8777	T7-2-45	12-01-88	02-01-89
88-9133	T13-2.5-01	12-05-88	02-01-89
88-9134	T13-2.5-12	12-05-88	02-01-89
88-9135	T13-2.5-23	12-05 <b>-</b> 88	02-01-89
88-9136	T13-2.5-34	12-05-88	02-01-89
88-9137	T13-2.5-45	12-05-88	02-01-89
88-9138	T13-2.5-910	12-05-88	02-01-89
88-9139	T16-0-01	12-07-88	02-01-89
88-9140	T16-0-12	12-07-88	02-01-89
88-9141	T16-0-23	12-07-88	02-01-89
88-9142	T16-0-34	12-07-88	02-01-89
88-9143	T16-0-45	12-07-88	02-01-89
88-9144	T16-0-1012	12-07-88	02-01-89
88-9190	T7-2-910B	12-09-88	02-01-89
88-9191	T7-2-1015	12-09-88	02-01-89
88-9192	10-01	11-30-88	02-01-89
88-9193	10-12	11-30-88	02-01-89
88-9194	10-23	11-30-88	02-01-89
88-9195	10-34	11-30-88	02-01-89

to: from: page 2	Project File James Good, Quality Assurance Officer		55-1643-03(0241A March 1, 198
88-9196	10-45	11-30-88	02-01-89
88-9197	10-230 (Duplicate)	11-30-88	02-01-89
88-9198	10-1015	11-30-88	02-01-89
88-9231	T2-1-01	12-13-88	02-01-89
88-9232	T2-1-12	12-13-88	02-01-89
88-9233	T2-1-23	12-13-88	02-01-89
88-9234	T2-1-34	12-13-88	02-01-89
88-9235	T2-1-45	12-13-88	02-01-89
88-9236	T2-1-78	12-13-88	02-01-89
89-4	T2-1-120 (Duplicate)	12-13-88	02-01-89

These marine sediment core samples were collected between November 16 and December 13, 1988, and generally were received by the laboratory within six days following collection. Sample 2-120 (Duplicate) was received 23 days after sample collection. Mercury was analyzed on January 27, 1989, thus exceeding the 28-day holding time limit for all samples. All mercury results will be flagged as estimates (J or N). Other metals were analyzed well within the six-month holding time requirements.

The initial calibration verification (ICV) percent recovery for the colorimetric analysis of arsenic on January 31 (35 percent) was less than the 90 percent minimum control limit. Arsenic results for the following samples may be biased low and will be flagged as estimates (J):

10A-01	T7-2-12	T7-2-34	T13-2.5-01	T13-2.5-23
T7-2-01	<b>T7-2-23</b>	T7-2-45	T13-2.5-12	T13-2.5-34

The ICV recovery for mercury (129 percent) exceeded the 120 percent upper control limit but no action was taken to qualify data because mercury was not detected in associated samples.

Limited sample volumes did not allow the laboratory to analyze laboratory duplicate samples for barium and pre-digestion spikes for barium and zinc.

The relative percent differences (RPDs) between results for field duplicate samples 10-23 and 10-230 were 127 percent for arsenic and 88 percent for zinc. The RPDs between field duplicates 2-12 and 2-120 were 50 percent for lead and 73 percent for zinc. When these same field duplicates were tested for total metals, the RPDs for arsenic, lead, and zinc were all less than 30 percent. The high RPDs for EP Tox metals indicate that extractable metals concentrations are more variable than total metals concentrations and additional analytical errors may be introduced by the extraction procedure. Field duplicate results were not used to qualify sample data.

to: from: Project File

James Good, Quality Assurance Officer

55-1643-03(0241A) March 1, 1989

page 3

A review of the raw data revealed an error in the zinc calculations for sample T7-2-34. The correct result for this sample is 1.18 ppm zinc not 0.12 ppm. The laboratory is sending corrected forms to document the error.

Other laboratory QA parameters tested were within control limits established in the project QA plan.

JG:kjr

Project File February 21, 1989

55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re: MEMO # MSC-1

to:

QA review: ASARCO RI/FS, Marine Sediment Coring Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	Parametrix <u>I.D. #</u>	Sample Date	Extraction Date	Analysis Date
1334773	10-01	11/30/88	12/13/88	12/27/88
1334774	10-12	11/30/88	12/13/88	12/27/88
1334775	10-23	11/30/88	12/13/88	12/27/88
1334776	10-34	11/30/88	12/13/88	12/27/88
1334777	10-45	11/30/88	12/13/88	12/27/88
1334778RE	10-230	11/30/88	12/13/88	12/29/88
1334779RE	10-1015	11/30/88	12/13/88	12/29/88
1334780	T-7-2-01	12/01/88	12/13/88	12/27/88
1334781	T-7-2-12	12/01/88	12/13/88	12/29/88
1334782	T-7-2-23	12/01/88	12/13/88	12/29/88
1334783	T-7-2-34	12/01/88	12/13/88	12/29/88
1334784	T-7-2-45	12/01/88	12/13/88	12/29/88
1335592	Method Blank		12/13/88	12/23/88
1335587	Unspiked		12/13/88	12/23/88
1335588	M. Ŝpike		12/13/88	12/23/88
1335589	M. S. Dup.	***	12/13/88	12/23/88

These marine core samples were collected on 11/30/88 and extracted on 12/13/88. This exceeds the seven day holding time limit so all the results from these samples will be flagged as estimates (J) or estimated detection limits (N).

The percent recovery in the matrix spike and matrix spike duplicate samples were out of limits for seven of the eleven spike compounds.

from: Bob Sullivan, Quality Assurance Officer

February 21, 1989

Page 2

There were trace levels (below the detection limit) of di-n-butylphthalate in the method blank. Trace amounts were also found in most of the samples indicating a lab contamination problem for that compound. However, since the levels in the blanks and samples were similar and below the calibrated detection limits for the system no qualifications are required.

# LLI# 1334773 10-01

The surrogate recovery of 2,4,6-tribromophenol was above the control limits for this sample. Since the data is being flagged because of the holding time problem, no addition qualifications are needed for the high surrogate recovery.

All other QA parameters for this sample were within the limits established in the project QA plan.

# LLI# 1334774 10-12

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1334775 10-23

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

### LLI# 1334776 10-34

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

from: Bob Sullivan, Quality Assurance Officer

February 21, 1989

Page 3

#### LLI# 1334777 10-45

The surrogate recovery of 2,4,6-tribromophenol was above the control limits for this sample. Since the data is being flagged because of the holding time problem, no addition qualifications are needed for the high surrogate recovery.

All other QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

## LLI# 1334778RE 10-230

This sample was re-injected because the recovery of the internal standard perylene-d12 was out of limits. All QA parameters for the re-injection were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1334779RE 10-1015

This sample was re-injected because the recovery of the internal standard perylene-d12 was out of limits. All QA parameters for the re-injection were within the limits established in the project QA plan except for the holding time problem described above.

## LLI# 1334780 T-7-2-01

The surrogate recovery of 2,4,6-tribromophenol was above the control limits for this sample. Since the data is being flagged because of the holding time problem, no addition qualifications are needed for the high surrogate recovery.

All other QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1334781 T-7-2-12

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

from: Bob Sullivan, Quality Assurance Officer

February 21, 1989

Page 4

## LLI# 1334782 T-7-2-23

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

## LLI# 1334783 T-7-2-34

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

## LLI# 1334784 T-7-2-45

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

Project File February 21, 1989 55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re: MEMO # MSC-2

to:

QA review: ASARCO RI/FS, Marine Sediment Coring Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster I.D. #	ParametrixI.D. #	Sample Date	Extraction Date	Analysis Date
1337281	T-13-2.5-12	12/5/88	12/19/88	1/5/89
1337282 1337283	T-13-2.5-23 T-13-2.5-34	12/5/88 12/5/88	12/19/88 12/19/88	1/5/89 1/4/89
1337284	T-13-2.5-45	12/5/88	12/19/88	1/4/89
1337285 1337286	T-13-2.5-910 T-16-0-01	12/5/88 12/7/88	12/19/88 12/19/88	1/4/89 1/4/89
1337287	M. Spike	12/7/88	12/19/88	1/4/89
1337288 1337289	M. S. Dup. T-16-0-12	12/7/88 12/7/88	12/19/88 12/19/88	1/4/89 1/5/89
1337290	T-16-0-23	12/7/88	12/19/88	1/5/89
1337291 1337292	T-16-0-34 T-16-0-45	12/7/88 12/7/88	12/19/88 12/19/88	1/4/89 1/5/89
1337293	T-16-0-1012	12/7/88	12/19/88	1/4/89
1337294	METHOD BLA	NK .	12/19/88	12/31/88

These marine core samples were collected on 12/5 and 12/7/88 and extracted on 12/19/88. This exceeds the seven day holding time limit so all the results from these samples will be flagged as estimates (J) or estimated detection limits (N).

The sample selected for the Matrix Spike and Duplicate runs (1337286) had to be diluted by a factor of 50 so the MS/MSD results are not reliable as a result 7 of 11 compounds were below the recovery limits for these runs. Since the MS/MSD results alone are not intended to evaluate the precision and accuracy of individual samples no action was taken to qualify or reject the sample results.

All the other QA parameters for this sample were within the limits established in the project QA plan.

to: Project File #55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer

February 21, 1989

Page 2

#### LLI# 1337281 (T-13-2,5-12)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337282 (T-13-2.5-23)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337283 (T-13-2.5-34)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337284 (T-13-2,5-45)

Butylbenzylphthalate was detected at the detection limit in the wet weight analysis but not listed as detected in the dry weight run. The laboratory indicated that the discrepancy is due to a rounding problem. Therefore butylbenzylphthalate will be considered detected at the estimated detection limit and flagged with a (J) because of the holding time problem listed above.

All other QA parameters for this sample were within the limits established in the project QA plan.

#### LLI# 1337285 (T-13-2.5-910)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

to: Project File #55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer

February 21, 1989

Page 3

#### LLI# 1337286 (T-16-0-01)

This sample was run straight, and also diluted by a factor of 10 and 50 before acceptable results were obtained. This was the sample used for the matrix spike analysis so the dilution rate put the spike recoveries below the detection limits of the system therefore, the MS/MSD results are not applicable to these samples.

All other QA parameters for this sample were within the limits established in the project

QA plan except for the holding time problem described above.

#### LLI# 1337289 (T-16-0-12)

Benzo(b) and Benzo(k)fluoranthene could not be resolved so the results are combined and reported as Benzo(b)fluoranthene. All other QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337290 (T-16-0-23)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337291 (T-16-0-34)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337292 (T-16-0-45)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1337293 (T-16-0-1012)

The surrogate recovery of 2,4,6-tribromophenol was above the control limits for this sample. All other QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### MEMORANDUM

to: Project File February 21, 1989 55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re: MEMO # MSC-3

QA review: ASARCO RI/FS, Marine Sediment Coring Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

Lancaster	Parametrix			
<u>I.D. #</u>	I.D. #	Sample Date	Extraction Date	Analysis Date
1330790	10A-01	11/16/88	11/29/88	12/3/88
1330791	10A-12	11/16/88	11/30/88	12/9/88
1330792	10A-23	11/16/88	11/30/88	12/9/88
1330793	10A-34	11/16/88	11/30/88	12/9/88
1330794	10A-45	11/17/88	11/30/88	12/4/88
1331588	10A-78	11/17/88	11/29/88	12/5/88
U.S.Day 335	***		11/30/88	12/2/88
M.S.Day 335			11/30/88	12/2/88
M.S.D.Day 335	; <del></del>		11/30/88	12/2/88
Method Blank			11/30/88	12/2/88

These marine core samples were collected on 11/16 and 11/17/88 and extracted on 11/29 and 11/30/88. This exceeds the seven day holding time limit so all the results from these samples will be flagged as estimates (J) or estimated detection limits (N).

The percent recovery of 2,4-dinitrotoluene exceeded the control limits for the matrix spike and matrix spike duplicate samples. Since the MS/MSD results alone are not intended to evaluate the precision and accuracy of individual samples no action was taken to qualify or reject the sample results.

All the other QA parameters for these samples were within the limits established in the project QA plan.

#### LLI# 1330790 (10A-01)

This sample was re-extracted and injected due to surrogate recovery problems in the first run. All QA parameters were within the limits established in the project QA plan for the second run except for the holding time problem described above.

to: Project File #55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer

February 21, 1989

Page 2

#### LLI# 1330791 (10A-12)

Surrogate recoveries of 2-fluorobiphenol and nitrobenzene were below the control limits for this sample. No additional action is required since all the data is flagged as estimates because of the holding time problem described above.

The detection limits were higher than normal due to matrix interferences. The results of Benzo(b) and Benzo(k) fluoranthene could not be resolved so they are reported as Benzo(b)fluoranthene.

All other QA parameters for this sample were within the limits established in the project QA plan.

#### LLI# 1330792 (10A-23)

The detection limits were higher than normal due to matrix interferences. The results of Benzo(b) and Benzo(k) fluoranthene could not be resolved so they are reported as Benzo(b)fluoranthene.

All other QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1330793 (10A-34)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1330794 (10A-45)

All QA parameters for this sample were within the limits established in the project QA plan except for the holding time problem described above.

#### LLI# 1331588 (10A-78)

The sample was re-injected because surrogate recoveries did not meet control limits for the original injection. This re-injection was within surrogate recovery limits.

All other QA parameters were within the limits established in the project QA plan for the second run except for the holding time problem described above.

#### MEMORANDUM

to: Project File February 21, 1989 55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer Revised: March 2, 1989

re: MEMO # MSC-4

QA review: ASARCO RI/FS, Marine Sediment Coring Laboratory Data

This QA review includes the following samples analyzed by Lancaster Laboratories, Inc. (LLI).

LancasterI.D. #_	Parametrix I.D. #	Sample Date	Extraction Date	Analysis Date
1339652	T2-1-2-01	12/13/88	12/30/88	1/7/89
1339653	T2-1-2-23	12/13/88	12/30/88	1/7/89
1339654	T2-1-2-34	12/13/88	12/30/88	1/5/89
1339655	T2-1-2-45	12/13/88	12/30/88	1/5/89
1339656	T2-1-2-78	12/13/88	12/30/88	1/5/89
U.S.Day 365			12/30/88	1/5/89
M.S.Day 365		8888	12/30/88	1/5/89
M.S.D.Day 365	5		12/30/88	1/5/89
Method Blank			12/30/88	1/5/89

These marine core samples were collected on 12/13/88 and extracted on 12/30/88. This exceeds the seven day holding time limit so all the results from these samples will be flagged as estimates (J) or estimated detection limits (N).

There were trace levels (below the detection limit) of di-n-butylphthalate in the method blank. Trace amounts were also found in most of the samples indicating a lab contamination problem for that compound. However, since the levels in the blanks and samples were similar and below the calibrated detection limits for the system no qualifications are required.

All the other QA parameters for this sample were within the limits established in the project QA plan.

#### LLI# 1339652 (T2-1-2-01)

All QA parameters for this sample were within the limits established in the project QA plan for the second run except for the holding time problem described above.

to: Project File #55-1643-03(0241a)

from: Bob Sullivan, Quality Assurance Officer

February 21, 1988

Page 2

#### LLI# 1338756 (T7-2-910B)

All QA parameters for this sample were within the limits established in the project QA plan for the second run except for the holding time problem described above.

### Final Report

# ASARCO Tacoma Smelter Remedial Investigation

Volume 4 — Baseline Risk Assessment

Environmental Toxicology International, Inc.



## BASELINE RISK ASSESSMENT

## TACOMA PLANT

Prepared for

ASARCO INCORPORATED

**APRIL 1989** 

Plaza 600 Building Sixth and Stewart, Suite 700 Seattle, WA 98101 USA Telephone (206) 441-6142 Facsimile (206) 443-1812 Telex 4947618 ETI UI



#### TABLE OF CONTENTS

EXECUTIVE SUMMARY	
I. INTRODUCTION	. 1
A. SITE HISTORY AND CHARACTERIZATION	1
B. FOCUS AND LIMITATIONS OF STUDY	
1. Exposure Scenarios of Concern	
2. Data Limitations	
II. HAZARD IDENTIFICATION	
A. SAMPLING	.3
1. Soils	
2. Air	5
B. INDICATOR CHEMICAL SELECTION	.6
1. Basis of Selection	.6
a. Site Concentrations	
b. Routes and Frequency of Exposure	
c. Exposed Population	
d. Toxicity Evaluation	
2. Indicator Chemicals	
a. Metals	
(i). Antimony	
(ii). Arsenic	
(iii). Cadmium	
(iv). Chromium	
(v). Copper	
(vi). Lead	.18
(vii). Mercury	19
(viii). Nickel	
b. Organic Chemicals	
(i). Dibenzofuran	
(ii). Dibenzothiophene	
(iii), HPAHs	
(iv). m-Nitroaniline	
(v). PCBs	25
(vi). Non-detected chemicals with	
high detection limits	25
A. EXPOSURE SCENARIOS	27
1. Onsite Residential	27
2. Onsite Industrial	29
3. Offsite Residential	29
B. Routes and Pathways of Exposure	29
1. Ingestion of Soil	.31
2. Ingestion of Vegetables Grown at the Site	
a. Factors Influencing Uptake of Metals	
by Plants	.34
b. Determination of Metal Uptake by Crops	35
	96



(ii). Cadmium	
(iii). Copper	
(iv). Lead	
(iv). Mercury	
3. Exposure to Water	
4. Inhalation	
5. Dermal Absorption	
a. Inorganic Chemicals	
b. Organic Chemicals	
6. Exposure to Slag	
C. INTAKE RATES	
1. Soil Ingestion	
2. Home-Grown Vegetable Ingestion	
3. Dust Inhalation	
4. Dermal Contact	.49
D. EXPOSURE CONCENTRATIONS	
1. Soil	
a. Degradation of Chemicals	
b. Calculation of Exposure Concentrations	
2. Concentration of Metals in Vegetables	
3. Concentration of Metals in Airborne Dust	
4. Offsite Deposition of Fugitive Dust	.52
E. POPULATIONS AT RISK AND DURATION OF EXPOSURE	. 53
1. Onsite Residents	. 53
2. Industrial Workers	. 56
3. Offsite Residents	. 56
F. CALCULATION OF DOSE	.57
G. SUMMARY	. 57
IV. TOXICITY ASSESSMENT	. 60
A. TOXICITY CRITERIA	.60
1. Criteria for Non-Carcinogenic Effects	
2. Criteria for Carcinogenic Effects	. 62
3. Criteria for Ambient Levels	
a. PEL/TLV	
b. AAL	
B. CHEMICALS OF CONCERN	
1. Antimony	
2. Arsenic	
3. Cadmium	
4. Chromium	-
5. Copper	
6. Lead	.68
7. Mercury	69
8. Nickel	.70
9. Polcyclic Aromatic Hydrocarbons (PAHs)	.71
10. Polychlorinated Biphenyls (PCBs)	71
11. Dibenzofuran	72
a. Toxicity	
b. Carcinogenicity	72



---

c. Mutagenicity	4
V. RISK CHARACTERIZATION	'6
A. CARCINOGENIC RISKS	<b>'7</b>
1. Comparison of Risks Among Carcinogenic	_
Chemicals	<b>'7</b>
a. Arsenic	7
b. HPAHs	1
c. Chromium	1
d. Cadmium	1
e. PCBs	2
f. Nickel	2
2. Comparison of Carcinogenic Risks Among	
Exposed Populations	2
B. NON-CARCINOGENIC RISKS	
1. Comparison of Non-carcinogenic Risks	
Among Chemicals	3
a. Lead	6
b. Antimony	6
c. Copper	6
d. Cadmium	7
e. Mercury	7
2. Potential Additive Effects of Metals	8
3. Comparison of Non-carcinogenic Risks Among	
Exposed Populations	9
VI. SUMMARY AND CONCLUSIONS	0
VII. REFERENCES	3
APPENDIX A	
Indicator Chemical Selection	<u>1</u>
APPENDIX B	
Example Calculations	3-1
APPENDIX C	
Concentrations of Metals in Fugitive Dust	:-1
APPENDIX D	
Additional Toxicological Information for Selected	
Chemicals of Concern	) <b>-</b> 1
APPENDIX E	
Uncertainty in Risk Assessment	<b>;-1</b>



#### LIST OF FIGURES

Figure 1:	Site Sampling Map
Figure 2:	Exposure Pathways of Concern and Populations at Risk for Contaminants in Soil
Figure 3:	Total Carcinogenic Risk - "Typical" Exposure  Conditions
Figure 4:	Total Carcinogenic Risk - "Worst Case" Exposure
Figure 5:	FDM - 1983 Annual Arsenic Concentrations
Figure 6:	FDM - 1983 Annual Arsenic Deposition



#### LIST OF TABLES

Table II-A:	Current Site Concentrations of Indicator Chemicals in Soil (ppm)
Table II-B:	Physical Characteristics of Indicator Chemicals
Table II-C:	Ambient Levels of Metals in Air, Background Levels, and Acceptable Ambient Levels (AAL)
Table II-D:	Comparison of Maximum Ambient Levels to State  Guidelines and Background Levels
Table III-A:	Routes of Concern for Indicator Chemicals
Table III-B:	Percent Absorption Assumed by Route of Exposure
Table III-C:	Plant Uptake Rates and Phytotoxicity Levels in Soil for Metals of Concern
Table III-D:	Concentration of Metals in Surface Water Runoff and Acute Exposure Estimates for Children
Table III-E:	Intake Rates for Different Age Groups
Table III-F:	Current Site Soil Concentrations of Indicator Chemicals for Ingestion and Dermal Routes of Exposure (ppm)
Table III-G:	Correction Factors for Duration of Exposure
Table III-H:	Dose Summary (mg/kg/day)
Table IV-A:	Toxicity Criteria for Non-Carcinogenic



*:* }

Table IV-B:	Toxicity Criteria for Carcinogenic Effects
Table IV-C:	Onsite Eight-Hour Maximum Concentration
	Compared to Occupational Limits (OSHA PEL) 65
Table V-A:	Total Carcinogenic Risk - "Typical"
	Exposure Conditions
Table V-B:	Total Carcinogenic Risk - "Worst-Case"
	Exposure Conditions
Table V-C:	Hazard Indices for Non-Carcinogenic Effects -
	"Typical" Exposure Conditions (Dose/AIC)
Table V-D:	Hazard Indices for Non-Carcinogenic Effects -
	"Worst-Case" Exposure Conditions (Dose/AIC)
Table C-1:	Ambient Concentration in Airborne Dust
Table C-2:	Deposition ConcentrationsFDM (g/m <sup>2</sup> )



### BASELINE HEALTH RISK ASSESSMENT EXECUTIVE SUMMARY

#### Background

The Tacoma Plant, owned by ASARCO Inc., operated as a smelter from 1890 to 1985. The main activities were the smelting of copper and the production of various byproducts including arsenic and liquid sulfur dioxide. The site covers 67 acres bordering Commencement Bay, the town of Ruston, and sections of urban Tacoma, Washington.

Under the terms of a 1986 consent order, ASARCO Inc. is required to demolish various facilities associated with copper smelting at the Tacoma Plant, and to conduct a Remedial Investigation and Feasibility Study of the site in agreement with the U.S. Environmental Protection Agency, Region X. In accordance with the consent order, Asarco has already completed some site remedial activities such as removal of selected buildings.

As part of the Remedial Investigation, Asarco has retained Environmental Toxicology International, Inc. (ETI), to perform a baseline health risk assessment to estimate human health risks associated with lifetime exposure to (1) the chemicals presently in the soil at the site and (2) offsite concentrations of metals in fugitive dust. The three hypothetical exposure scenarios, developed cooperatively with Asarco and the EPA, evaluate the risks from residential site use, industrial site use, and offsite residential exposure to fugitive dust. Risks to offsite residents due to the existing levels of metals in soils were calculated in the Ruston/Vashon Island Endangerment Assessment.

This report was prepared for the exclusive use of ASARCO Inc. and the EPA. All work was conducted in accordance with generally accepted state and federal guidelines at the time of our investigation. No other warranties, expressed or implied, are made as to the professional advice provided.

#### Indicator Chemicals

The indicator chemical selection process for this assessment involved a detailed review of the site characterization data, regional background concentrations, soil analytical results, ambient levels in air, chemical toxicity, and chemical environmental fate and transport. Those chemicals that pose the greatest potential health risk at the site were chosen as "indicator chemicals".

The majority of hazardous substances detected in site soils are metals associated with the smelting and refining operations. The metals selected as indicator chemicals at the site are antimony, arsenic, cadmium, copper, chromium, lead, mercury, and nickel. Organic chemicals of concern at the site are the high-molecular-weight variety of polycyclic aromatic hydrocarbons (HPAHs) and PCBs. These organic chemicals occur in distinct "hot spots" of contamination but are not distributed throughout the site.

Unsubstituted dibenzofuran, unsubstituted dibenzothiophene, and m-nitroaniline are conservatively included as possible chemicals of concern. These chemicals lack the necessary EPA criteria to be quantitatively evaluated by the indicator chemical screen. The



available evidence indicates that these chemicals are of minor health concern at the few locations where they were detected on site.

#### Exposure Assessment

Three separate scenarios are considered that cover a range of possible exposure conditions for hypothetical populations exposed to the site. These scenarios assume that current soil conditions remain unchanged (no-action alternative). A residential scenario, which considers lifetime exposure to the site in its current condition by a hypothetical resident living on the site, is used to estimate the worst-case exposure scenario. An industrial scenario considers the potential exposure for workers if the site is developed for heavy or light industry. An offsite residential scenario evaluates exposure to fugitive dust by a population residing near the boundaries of the Asarco property.

The relevant pathways and routes of exposure to the indicator chemicals at the site depend on the type of chemical and the population of concern. For onsite residents, the most important pathways were determined to be ingestion of metals and organic chemicals in soil, ingestion of metals in home-grown vegetables, inhalation of metals in dust, and dermal absorption of organic chemicals in soil. Workers are assumed to have the same routes of exposure as residents, except that ingestion of home-grown vegetables is not included as an exposure pathway. For offsite residents, the pathways of concern are inhalation of metals in fugitive dust and ingestion of metals in soil from deposition of dust from the site.

Exposure to surface water in the cooling pond on site appears to be a less significant exposure pathway than exposure to surface soil. This determination is based on an examination of cooling pond sediment analytical data. Copper may be an exception given the elevated levels of this metal in soil near the pond. A screening evaluation of acute exposure to total metals in storm water runoff yielded no significant exposures, assuming one-time ingestion exposure by children playing in puddles. Exposure to fish in Commencement Bay has been studied by the Commencement Bay/Nearshore Tide Flats Feasibility Study and thus is not duplicated in this report.

#### Toxicity Assessment

The toxicity assessment section summarizes the toxic effects associated with the calculated doses of the indicator chemicals to which hypothetical onsite and offsite populations are exposed. The EPA criteria used to calculate the quantitative risk estimates from the exposure doses are described. The toxicological properties of many of the indicator chemicals are presented in more detail in Appendix C, including discussion of effects associated with higher concentrations of these chemicals.

Dibenzofuran and m-nitroaniline were evaluated qualitatively in the toxicity assessment because the available data were insufficient to evaluate their associated health risks quantitatively. The available toxicological information does not indicate that these chemicals would be a major health concern at the low levels that occur on the site. Moreover, neither have been shown to be carcinogenic and thus exclusion of these chemicals from the quantitative risk assessment will not affect the overall carcinogenic risk for the site. Dibenzothiophene lacks sufficient toxicological data to be evaluated. This chemical is structurally similar to dibenzofuran and was detected at lower levels.



#### Risk Characterization

A range of quantitative risk estimates are given for both carcinogenic and non-carcinogenic effects. Carcinogenic risk is the risk of developing but not necessarily dying of cancer.

Risk estimates for carcinogenic effects due to exposures at the Asarco site are compared to target risk levels set by the EPA  $(10^{-4} \text{ to } 10^{-7})$ . Non-carcinogenic effects were assessed by comparing the dose of each indicator chemical by each route of exposure to the acceptable daily intake for chronic exposure developed by the EPA.

The major determinant of carcinogenic risk for the site is arsenic, primarily via ingestion. Risks are highest for the hypothetical residential use scenario (10<sup>-1</sup> to 10<sup>-3</sup>) and about an order of magnitude lower for the industrial use scenario.

Risks associated with HPAHs are 10-3 to 10-5 for "worst-case" and "typical" exposure respectively, assuming that all HPAHs are the carcinogenic benzo[a]pyrene. HPAHs were localized to a few "hot spots" and were not detected in most areas.

The risks for the other carcinogenic substances (inhalation of chromium, nickel, and cadmium, and oral and dermal exposure to PCBs) are 10-5 or lower and within EPA guidelines for allowable exposure.

Risks to offsite residents due to inhalation of carcinogenic metals in fugitive dust are within allowable guidelines. Worst-case risks are 10-4 at the site boundary and 10-5 for more realistic exposure at 0.4 kilometer from the site boundary. Arsenic is the primary source of this risk. Based on "worst-case" calculations, deposition of arsenic in fugitive dust is not expected to increase the lifetime risk to offsite residents measurably above current risks calculated for soil ingestion, which have been estimated to be 10-2 to 10-3 (Black and Veatch, 1988). Despite this relatively high risk (one-in-a-hundred to one-in-a-thousand), epidemiological studies of the surrounding community have not shown statistically significant increases in morbidity or mortality relative to the general population (summarized by Black and Veatch, 1988). Although epidemiological studies are inherently weak statistically, this discrepancy may also be explained by the tendency for current risk assessment methodology to overestimate cancer risks to most residents near this site and thus to theoretically predict far more cases of cancer in the population than are actually observed. Few individuals would match the worst-case exposure assumptions used such as continuous lifetime residency and high contaminant intake rates.

Major determinants of non-carcinogenic risks are *ingestion* of lead, and less importantly ingestion of antimony, copper, cadmium, and mercury. The latter metals are of concern under "worst-case" exposure conditions but not for more realistic conditions ("typical"). Assuming that children are living at the site with present soil conditions, ingestion of lead in soil is conservatively estimated to result in a dose that is 60 times the "acceptable" dose under "worst-case" conditions and four times the "acceptable" dose under "typical" conditions. By comparison, exposure for workers at the site would result in a "worst-case" ingestion dose for lead of five times the acceptable level. "Worst-case" exposure assumes that workers ingest soil during earth-moving activities. Under "typical" exposure



conditions, ingestion by workers results in dose estimates below the acceptable level of chronic exposure.

The above-mentioned risk estimates for exposure to lead at the site reflect the conservative assumptions used in this risk assessment. The conservative nature of the lead exposure assumptions used is further indicated by the lack of an increase in blood lead levels in children living near the site due to increased lead levels in soil. Blood lead levels of school children living within a mile of the smelter apparently were not elevated in this area relative to a control population that was not exposed to the smelter (Glass, 1984). A conservative approach to risk estimation is justified, however, given the higher lead soil concentrations on site (average = 3,800 ppm) and the growing regulatory concern that adverse effects in children may occur at lower blood lead levels than previously believed to be safe (USEPA, 1988b).

Estimated non-carcinogenic risks via inhalation of lead by onsite or offsite populations do not exceed state and federal guidelines and are therefore not expected to cause adverse effects.

#### Conclusions

Residential use of the site would require reduction of primarily arsenic and secondarily lead and HPAH levels. Risks from all other indicator chemicals are within EPA allowable levels under typical exposure conditions. Industrial use of the site will mainly require reduction of arsenic levels. Worst-case offsite arsenic levels in air are within the 10-4 to 10-7 range of target risk levels recommended by the EPA. Worst-case offsite deposition of arsenic in fugitive dust poses a very small increase in soil concentration and risk relative to the existing levels off site.

These conclusions are based on conservative assumptions with regard to acceptable public health exposures as outlined by state and federal guidelines.



#### I. INTRODUCTION

Environmental Toxicology International, Inc. (ETI), was retained by ASARCO Inc. to assess the risks to human health associated with their Tacoma Plant located on the border between Ruston and Tacoma, Washington. This report was completed under the terms of an agreement with the U.S. Environmental Protection Agency, Region X office, and is included as Volume 4 of the Remedial Investigation prepared for the site (Parametrix et al., 1989).

This introductory section describes the site and its history of use, and outlines the focus of the health risk assessment.

#### A. SITE HISTORY AND CHARACTERIZATION

The Tacoma Plant, owned by ASARCO Inc. has been used for smelting operations since 1890. The site covers 67 acres of the 97 acres of Asarco property and borders Commencement Bay, the town of Ruston, and sections of urban Tacoma. The surrounding land use is primarily residential; a yacht club and several commercial buildings are also located nearby.

The main function of the Tacoma plant was to smelt and refine copper from copper-bearing ores and concentrates that were shipped in from other locations. It was in full operation until 1979. During the plant operation, many of the by-products of copper smelting were further refined to produce other marketable products. Dust collected during the copper smelting process was roasted to yield arsenic trioxide and metallic arsenic. Sulfur dioxide from the converter operation was used to produce sulfuric acid and liquid sulfur dioxide. Slag produced by the smelter was recovered and sold as rip-rap, ornamental rock, and road ballast by Industrial Mineral Products, Inc. This material was also used as fill material on the site and was deposited at the water's edge, thereby extending the property out into Commencement Bay approximately 450 feet. Northwest of the site is a small peninsula (2,000 feet long) formed from deposited slag. The slag overlays granular soil, wood wastes, and beach gravel deposits.

After 1979, the refinery was closed and copper produced from the smelting operation was shipped to Texas for refining. Emission control devices on the smelter were updated and replaced between the years of 1974 and 1985. The smelter section of the plant was closed in March 1985 following a market decline in demand for copper and increased overhead due to pollution controls needed for operation. Arsenic production continued until February of 1986, at which time the plant was closed permanently.



Site stabilization activities initiated under a 1986 consent order with U.S. EPA Region X include the demolition of facilities associated with copper smelting and arsenic production at the Tacoma Plant. The southern sections of the plant, where the arsenic plant, electrostatic precipitators and brick flues were located, have been dismantled and the site graded. Dismantling of equipment and administrative tasks continue at the site.

#### B. FOCUS AND LIMITATIONS OF STUDY

#### 1. Exposure Scenarios of Concern

ETI was retained to assess the human health risks caused by exposure to substances of potential concern identified in site surface soils and assuming no remediation of current soil concentrations. Three exposure scenarios were considered: onsite residential, onsite industrial, and offsite residential. These scenarios were developed by agreement with the EPA and ASARCO Inc. to represent hypothetical site uses and associated exposure from worst-case (residential) to more probable (industrial). In addition, current exposure to offsite residents via fugitive dust from the site was also considered.

The information and sampling data available for completing this report are from the Ruston/Vashon Island Endangerment Assessment (Black and Veatch, 1988), the Task 1 report for the site (Parametrix, 1987), the Interim Remedial Investigation report (Parametrix, 1988), and Volumes 1 and 2 of the Remedial Investigation report (Parametrix et al., 1989).

#### 2. Data Limitations

The accuracy of this report depends in part on the quality and representativeness of the available sampling, exposure, and toxicological data. Where information is incomplete, conservative assumptions were made so that risk to public health is not underestimated. For example, in absence of data on the specific chemical form of the metals, we assumed that these metals were present in the most toxic form possible at the site. Section IV presents an evaluation of uncertainties in the risk assessment resulting from data limitations.

This report was prepared for the exclusive use of ASARCO Inc. and the EPA. All work was conducted in accordance with generally accepted state and federal guidelines at the time of our investigation. No other warranties, expressed or implied, are made as to the professional advice provided.



#### II. HAZARD IDENTIFICATION

#### A. SAMPLING

#### 1. Soils

Surface soil samples on the site were collected during the months of October and November in 1987 by Parametrix, Inc., as a part of Round 1 sampling (Figure 1). All information on sampling is reported in more detail in Volumes 1 and 2 of the Remedial Investigation (RI) report (Parametrix et al., 1989).

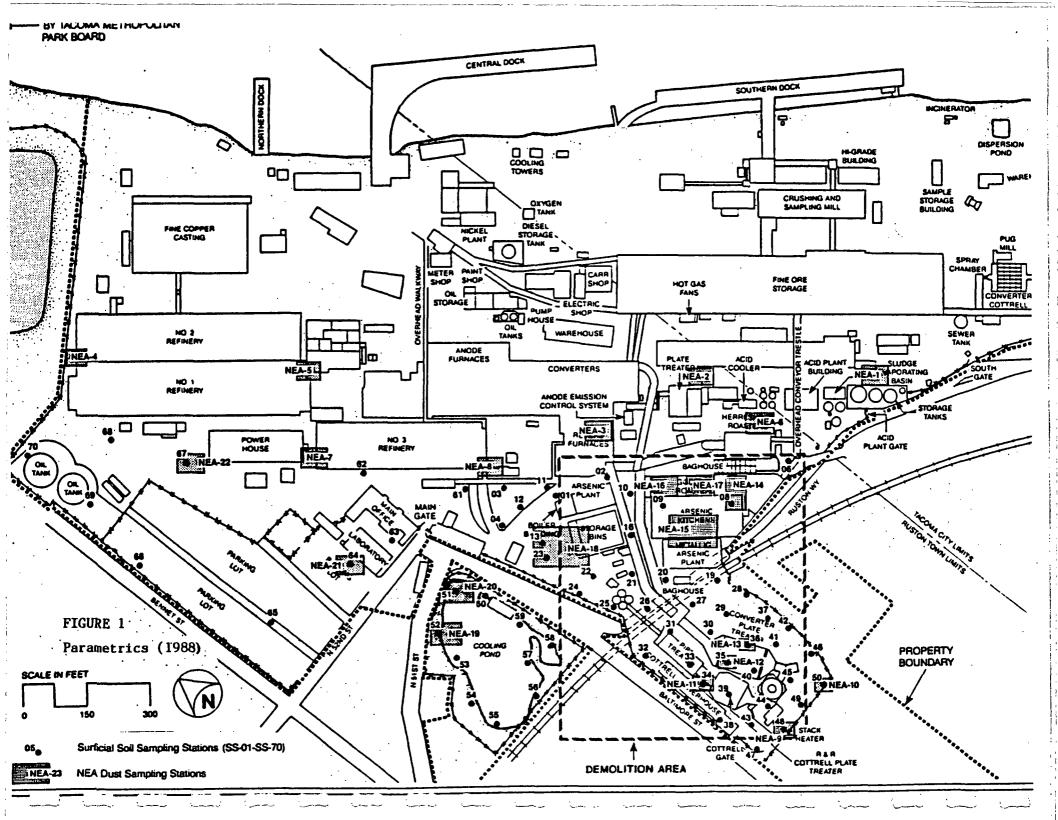
The site was divided into different sections based upon historical records of activities at the site that may have contributed to contamination of soils. These sections and the number of soil samples taken are as follows:

- 1) Ten soil samples were taken in the plant administrative area, which includes the parking lots, nearby laboratory, and oil tanks.
- 2) Ten soil samples were taken from the cooling pond area, including five samples from pond sediments taken as a part of Round 2 sampling.
- 3) 44 soil samples were taken from the site stabilization area, which includes the facilities associated with copper smelting processes and arsenic production.

In addition, seven to eight surface soil samples were taken during the installation of monitoring wells (see Figure 2-7 of Parametrix et al., 1989, for locations of surface samples taken from monitoring wells 4, 5, 7, 8, 10, 11, 12, and 13). The western portion of the plant was not sampled because it is mostly all slag deposits and pavement and has little exposed soil.

Surface soil samples were analyzed for hazardous substances list (HSL) semivolatile organics and metals. Detailed data tables for the site are presented in Volume 2 of the Remedial Investigation report (Parametrix et al., 1989). The sampling focused on the following possible contaminants at the site based on site history and results of compounds detected offshore (Tetra Tech, 1985):

Metals: arsenic, cadmium, chromium, lead, antimony, mercury, copper, zinc, nickel, silver, selenium, thallium, barium.





Base-Neutral Organics: dibenzofuran, chlorobenzenes, phthalate esters., dinitrotoluenes, low- and high- molecular-weight polycyclic aromatic hydrocarbons (LPAH and HPAH).

Acid Extractable Organics: 2-methylphenol, 4-methylphenol, dibenzothiophene, methylphenanthrenes, 1-methyl(2-methylethyl)benzene, biphenyls.

Other Analytes: dimethylaniline, uranium, polychlorinated biphenyls (PCBs).

In addition, several other chemicals in the base-neutral and acid extractable class were also analyzed by the laboratory. The complete list of chemicals evaluated in this report is presented in Appendix A (Key to Sample Codes for Organic Chemicals). All of the metals suspected as possible contaminants based on site history were present on the site in some measurable concentration. Some chemicals in each of the other groups were not detected. Of the base-neutral organics of concern, dichlorobenzenes were not detected. Of the acid extractable organics of concern, 2-methylphenol, 4-methylphenol and 1-methyl(2-methylethyl)benzene were not detected. Dimethylaniline and uranium were also not detected.

The mean concentrations of the chemicals sampled at the site are presented as a part of the indicator chemical selection in Appendix A. A detailed description of the concentrations of the chemicals and their location can be found in Parametrix et al. (1989).

A total of 22 surface dust samples were also taken during the sampling. The data were used by TRC Environmental Consultants to determine particle sizes and relative concentrations of metals in airborne dust. This information was used to help determine exposure concentrations of metals in dust.

Smelter slag, which was used to fill a part of the property, is a solid, rock-like material composed of iron and aluminum silicates (90%) and smaller amounts of certain heavy metals and other materials. Three surface samples of slag contained mainly antimony, arsenic, copper, lead, nickel, and zinc (averages from 770 ppm for nickel to 14,917 ppm for antimony).

#### 2. <u>Air</u>

Arsenic in dust from the site has been monitored at several locations on and off the Asarco site since the 1970's. These measurements primarily represent the impacts of plant operations and, to a minor degree, plant demolition.



To determine the impact of arsenic in dust for current conditions, TRC Environmental Consultants predicted offsite exposure concentrations due to wind-blown dust from the inactive Asarco facility. TRC used the Industrial Source Complex/Long Term model (ISCLT) and the Fugitive Dust Model (FDM) as recommended by USEPA (1988d) to determine ambient levels and deposition of arsenic and other metals at the facility and on the surrounding areas. These results are reported for the metals of concern in the following sections. Volume 1 of the RI report (Parametrix et al., 1989) presents a detailed description of the modeling and results.

#### **B. INDICATOR CHEMICAL SELECTION**

#### 1. Basis of Selection

When many chemicals are present on site, EPA guidelines recommend focusing the evaluation on a group of "indicator chemicals" based on the inherent toxicity, quantity present, and behavior of the chemicals in the environment (USEPA, 1986c). These indicator chemicals are those that are of primary concern in determining site risks. The rationale behind the selection of indicator chemicals is that if no adverse health effects are expected to result from the chemicals of greatest known health concern, then the population at risk will also be protected from other chemicals not evaluated in the final risk characterization. In this assessment, the indicator chemical selection process involved a detailed review of the following:

- o Site concentrations
- o Routes and frequencies of exposure
- o Exposed population
- Chemical toxicity

Each of these steps are discussed in the following sections. In addition, this process is sensitive to the physical/chemical properties and environmental transport characteristics that may affect the exposure and health risk evaluation. These characteristics are discussed in detail for the chemicals selected as indicator chemicals.

#### a. Site Concentrations

To screen for chemicals based on toxicity and concentration, the mean concentration in site soils (Parametrix et al., 1989) was used as the representative concentration for that



chemical. In calculating the mean, concentrations that were below the limit of detection were assumed to be present in concentrations equal to half of the average detection limit (rather than zero). For chemicals that were not detected in any of the samples, half of the detection limit was used as a representative concentration to determine if the detection limit was sufficiently low to eliminate these chemicals from indicator chemical list based on low risk to public health.

In a few cases, the detection limit of an individual sample was higher than the highest concentration detected. To eliminate the effect of these artificially high detection limits on the mean, samples with detection limits greater than twice the average of the sample detection limits (including high limits) were eliminated from the data set in calculating exposure concentrations.

Ambient concentrations were evaluated for metals that generally have more toxic effects via inhalation of dust than by other routes of exposure (i.e., chromium, cadmium, nickel). The maximum annual average concentration for onsite exposure (FDM model) was conservatively used to screen for metals of potential concern in airborne dust.

#### b. Routes and Frequency of Exposure

Based on the environmental fate and transport characteristics of the chemicals detected at the site, the route of most concern for the metals and semi-volatile organic chemicals is ingestion. The exposure assumptions selected to screen for indicator chemicals are those that result in a conservative approximation of worst-case health effects that could result via ingestion of site soils.

Chemicals that have a high potential for exposure by another route are also evaluated for that route. For example, several metals present in dust at the site are carcinogenic via inhalation and not by ingestion. These metals were also screened assuming worst-case inhalation exposure.

Assumptions that were used to develop the indicator chemical screen are discussed in detail in the Exposure Assessment Section (Section III). To summarize, assumptions for non-carcinogenic chemicals were:

o The population at greatest potential risk is the most sensitive age group, i.e., a young child (body weight 10 kg; Black and Veatch, 1988; USEPA, 1986c).



- These young children (age zero to one year old) were conservatively assumed to ingest soil at the rate of children ages one to six (a "maximum" of 500 mg of soil per day; La Goy, 1987) every day of the year. As a comparison, a typical soil ingestion rate for one-to six-year-old children was also considered (100 mg/day; La Goy, 1987).
- o Absorption of all chemicals was assumed to be 100% of the most toxic form possible on site.

For carcinogens, the following conservative assumptions were made:

- o A resident (body weight 70 kg; USEPA, 1986c) spends a lifetime at the site and never leaves during this period. Because carcinogenic risks increase with exposure period, lifetime residents are the most exposed population.
- o Ingestion rate of soil is 200 mg/day for the entire lifespan (twice the worst-case soil intake rate of children ages six to 11; La Goy, 1987).
- o The inhalation rate is 20 m<sup>3</sup>/day for a lifetime (USEPA, 1986c).
- o Absorption of all chemicals is 100%.

#### c. Exposed Population

At this time, the population most directly exposed to site soils is the few remaining workers at the plant. Hypothetical use of the site as a residential area, however, would result in exposure to children and other members of the public that may be more sensitive to site chemicals. Therefore, in screening for indicator chemicals, we evaluated exposure to the most sensitive population: hypothetical onsite residents. We assumed for this study that the hypothetical residential population would be similar to the current residents in the Tacoma area.

#### d. Toxicity Evaluation

Current EPA criteria and the toxicological literature were reviewed in selecting acceptable dose and risk criteria to select the indicator chemicals of concern. Toxicity criteria for non-carcinogenic effects represent an allowable dose below which no adverse effects are expected. Carcinogenic criteria are potency factors which are used to compute the



carcinogenic risk associated with a given dose. See Section IV, Toxicity Assessment, for a complete description of these criteria.

Some chemicals that lacked specific EPA toxicity criteria could be evaluated with EPA criteria developed for structurally related chemicals. Where possible we selected related chemicals that were likely to be more toxic than the chemicals with the unknown criteria. For example, polycyclic aromatic hydrocarbons (most of which lack criteria) were evaluated with the criteria of one of the most potent carcinogens in this group (benzo[a]pyrene). For three detected chemicals, dibenzofuran, dibenzothiophene, and *m*-nitroaniline (3-nitroaniline), related compounds with toxicity criteria were not available. Consequently, these chemicals could not be quantitatively screened. They are conservatively selected as indicator chemicals and evaluated qualitatively. Twelve chemicals that were not detected also lack criteria (or related criteria) and thus their detection limits could not be evaluated quantitatively (see Appendix A). The detection limits of these undetected chemicals are therefore assumed to be sufficiently low to indicate these chemicals are not present at levels of health concern.

A chemical was included on the list of indicator chemicals if the worst-case exposure prediction yielded the following: (1) for non-carcinogenic effects, concentrations resulting in a dose that exceeded the relevant allowable level of exposure (EPA acceptable intake for chronic exposure [AIC] or EPA reference dose [RfD]); or (2) for carcinogenic effects, concentrations that would pose a cancer risk greater than 10-6. The EPA recommends target risk levels of 10-4 to 10-7 (USEPA, 1986c). This comparison is illustrated on the spreadsheets in Appendix A. If a chemical had both carcinogenic and non-carcinogenic effects, the more conservative exposure criterion was chosen.

For the metals with ambient data calculated by TRC (Parametrix et al., 1989), we also compared the highest concentrations on the site to the draft Acceptable Ambient Levels (AALs) developed for the general public by the Washington State Department of Ecology (WDOE, 1988). Section IV, Toxicity Assessment, describes these criteria in more detail.

Appendix A summarizes how the chemicals were evaluated in the indicator chemical selection. The results of the indicator chemical screen are outlined below.

#### 2. Indicator Chemicals

This section describes the results of the indicator chemical process, including the details of their selection, their physical characteristics, and environmental fate and transport properties. Table II-A presents the indicator chemicals and their concentrations measured



# TABLE II-A CURRENT SITE CONCENTRATIONS OF INDICATOR CHEMICALS IN SOIL (PPM)

CHEMICAL	MEAN	MINIMUM	MAXIMUM	
(etals				
Antimony	139.	<13.	3,350.	
Arsenic	9,776.	11.	262,250.	
Cadmium	67.	<0.25	498.	
Chromiuma	59.	21.	142.	
Copper	11,688.	41.	316,750.	
Lead	3,809.	12.	22,600.	
Mercury	<i>7</i> 9.	0.1	695.	
Nickel <sup>a</sup>	83.	<b>40</b> .	538.	
Organics				
Dibenzofuran	0.54	<0.40	7.2	
Dibenzothiopheneb	0.41	0.005	1.4	
HPAHsc	41.60	<0.40	885.	
M-nitroaniline	1.24	<2.00	11.9	
PCBs	0.82	<1.00	4.7	

(Parametrix et al., 1989)

<sup>&</sup>lt;sup>a</sup> These metals were selected as indicator chemicals based on potential health effects via inhalation of ambient dusts.

b Detection limits ranged from 0.3 to 20.0 ppm in most samples; samples with detection limits greater than 9.0 were not used in averaging. **Maximum** is the highest detected concentration.

e Mean is a summation of mean concentrations of all HPAHs sampled; minimum reports the detection limit at a location in which none of the HPAHs were detected; maximum is the total concentration of all HPAHs detected at the location with the highest concentrations.



in soil. Table II-B lists the physical properties of these chemicals. Concentration of metals in air and comparison to relevant background concentrations and AALs are shown in Table II-C and Table II-D.

#### a. Metals

The metals that were selected as chemicals of concern via ingestion were antimony, arsenic, cadmium, copper, lead, and mercury. These chemicals resulted in doses exceeding the allowable exposure levels by least two times. Nickel and chromium were selected as being of potential health concern for carcinogenic effects via inhalation.

The source of the metals of concern is likely to be the copper ore or additives of the refining process. An exception is chromium, for which the most likely source was the bricks from the furnace. These bricks were crushed and reused on site to recover the metals deposited on them. In the process, chromium in the bricks was also released.

In contrast to the above metals, selenium, silver, and thallium barely exceeded the acceptable level under worst-case exposure assumptions for non-carcinogenic effects; the resulting doses were 1.1 times the allowable doses (AIC) for these metals. [The average thallium concentration was also inflated by the high detection limits of the 90% of samples with non-detectable concentrations relative to the toxicity of this chemical.] Under typical exposure assumptions, concentrations of all three chemicals were an order of magnitude less than the allowable level. Therefore, selenium, silver, and thallium were not included as indicator chemicals because they are of relatively low health concern even assuming worst-case exposure. These metals are not carcinogenic and therefore their exclusion from the assessment does not affect calculations of overall carcinogenic risk of the site.

The metals that were selected as indicator chemicals are discussed separately (below).

(i). Antimony: The average antimony level in soil resulted in a worst-case dose that is one order of magnitude higher than the reference dose (RiD) for non-carcinogenic effects. Concentrations were highest in the site stabilization area adjacent to the former arsenic plant (Figure 1). The maximum annual average concentration in air was 0.04 ug/m<sup>3</sup>, which is more than an order of magnitude below the Acceptable Ambient Level (AAL) for this chemical. Thus, this chemical is not considered as an indicator chemical by the inhalation route.

Antimony is a relatively rare mineral whose chief source is stibnite (Sb<sub>2</sub>S<sub>3</sub>), a mineral found in hydrothermal veins and hot springs. Antimony is a heavy mineral with an high

TABLE II-B

PHYSICAL CHARACTERISTICS OF INDICATOR CHEMICALS

Chemical	CAS#	Molecular Weight	Vapor Pressure <sup>1</sup> (mm Hg)	Water Solubility (mg/l)	K <sub>oc</sub> 2 (ml/g)	log K <sub>ow</sub> 3	Bioconc.4 (1/kg)	Half Life5 (days)
Metals					· <del></del>		<del></del>	
Antimony	7440-36-0	122	1.0E+00	l	na	na	1	4.8
Arsenic	7440-38-2	75	0.0E+00	i	na	na	44	5
Cadmium	7740-43-9	112	0.0E+00	i	na	na	81	4.8
Chromium VI	7440-47-3	52	0.0E+00	t	na	na	16	<b>*</b> 3
Copper	7440-50-8	64	0.0E+00	t	na	na	200	
Lead	7439-92-1	207	0.0E+00	t	na	na	49	4.8 (air)
Nickel	7440-02-0	59	0.0E+00	l	na	па	47	
Mercury	7439-97-6	201	2.0E-03	t	na	na	5500	4.8 (air)
Organics				· : .				
Dibenzofuran	132-64-9	168	4.4E-03	1.0E-02	5.5E+03	4.12	1.4E+03	
HPAHs	50-32-8	252	5.6E-09	1.2E-03	5.5E+06	6.06	2.8E+04	434-496
m-Nitroaniline	99-09-2	138		1.1E+03				
PCB	1336-36-3	328	7.7E-05	3.1E-02	5.3E+05	6.04	1.0E+05	<b>*2-13</b>

References (USEPA 1986c, HSBD 1988, Merck 1988).

- 1. Vapor pressure is measured at a temperature range of 20 30 °C.
- 2. K<sub>OC</sub> = Organic-Carbon Partition Coefficient is a measure of the tendency for organics to be adsorbed by soil and sediment and indicates a compound's lipophilic nature.
- 3. Kow = Octanol-Water Partition Coefficient is a measure of how a chemical is distributed at equilibrium between octanol and water.
- 4. The bioconcentration factor is a measure of the tendency for a chemical in water to accumulate in fish tissue.
- 5. Half-life is the measure of persistence, or how long a chemical will remain, in various environmental media.
- 6. Half-life measured in soil unless designated by asterisk which designates water.

na = not applicable

t = insoluble

-- = no data



TABLE II-C

AMBIENT LEVELS OF METALS IN AIR, BACKGROUND LEVELS, AND ACCEPTABLE AMBIENT LEVELS (AAL)

CHEMICAL	BACKG	BACKGROUND		MAXIMUM ANN	MAXIMUM ANNUAL AVERAGEd		
	USA URBANa (range)	CITY CENTER <sup>b</sup> TACOMA		ISCLT on site	FDM on site		
ntimony	5E-04 - 2E-01	ina	1.2E+00	2.12E-02	4.21E-02		
Arsenic	2E-03 - 2E+00	3.3E-02	2.3E-04	1.34E-01	2.68E-01		
Cadmium	2E-04 - 7E+00	1.0E-03	5.6E-04	1.12E-03	2.23E-03		
Chromium	2E-03 - 7E+00	8.1E-03	ina	2.28E-03	4.56E-03		
Copper	3E-03 - 5E+00	2.1E-01	2.4E+00	1.40E-01	2.80E-01		
lickel	1E-00 - 3E-01	1.4E-02	2.0E-03	3.35E-03	6.70E-03		
æad	3E-02 - 1E+01	4.0E-01	4.9E-01	1.19E-01	2.38E-01		
Mercury	6E-04 - 5E-01	ina	1.2E-01	7.18E-02	1.44E-01		

NOTE: All units are in ug/m<sup>3</sup>



a Ranges are for United States urban areas (Schroeder, et al., 1987).

b PSAPCA (1986).

c WDOE (1988).

d TRC (Parametrix et al., 1989). ISCLT and FDM models used to estimate these concentrations.

e Ranges for inorganic mercury.
ina = Information not available

TABLE II-D



### COMPARISON OF MAXIMUM AMBIENT LEVELS TO STATE GUIDELINES AND BACKGROUND LEVELS

CHEMICAL	MAXIMUM ANNUAL AVERAGE FDM on site (MAA) (ug/m <sup>3</sup> )	MAA/AAL	MAA/BACKGROUND
Antimony	0.0421	0.04	na
Arsenic	0.268	1165.22	8.12
Cadmium	0.00223	3.98	2.23
Chromium	0.00456	na	0.56
Copper	0.280	0.12	1.33
Nickel	0.00670	3.35	0.48
Lead	0.238	0.49	0.60
Mercury	0.144	0.60	na

Note: Background data are from the city center of Tacoma (PSAPCA, 1986). MAA/AAL ratios exceeding one (unity) indicate ambient levels that exceed State guidelines (WDOE, 1988).

na = not available



boiling point. Belonging to the same periodic group as arsenic, antimony resembles it both chemically and physically. Arsenic, however, is much more toxic.

In the atmosphere, antimony is found as stibine gas (SbH3) and antimony trioxide (Sb2O3). Antimony trioxide has a very low vapor pressure, and therefore is not expected to be released into the atmosphere at normal environmental temperatures. Antimony is not likely to be removed by rain because of its low solubility. The residence time of antimony is dependent on its small particle size, low washout coefficients, and low dry deposition velocities (USEPA, 1985f).

In soil, antimony trioxide persists due to its low solubility, lack of reactivity, stability, and low vapor pressure.

Most of the antimony oxides in water are present in suspended solids. The major transport mode is sorption onto colloids in association with iron, aluminum, and manganese (USEPA, 1985f). Bioconcentration factors for freshwater fish and benthic invertebrates are relatively low (1-100; USEPA, 1985f).

(ii). Arsenic: Arsenic was selected as an indicator chemical because the inherent toxicity of this compound and its mean soil concentration resulted in a carcinogenic risk that was 10-2, or four orders of magnitude higher than 10-6. The arsenic concentrations in dust on site result in a risk that is 10-3, or three orders of magnitude higher than 10-6. The highest concentrations of arsenic were found at sample site SS-02, located in the stabilization area near the former arsenic plant (Figure 1).

Arsenic exists in the environment in various chemical states, the principal state of concern being tri- and pentavalent inorganic arsenic, methylated organic arsenic, and as arsenic hydride. The main source of naturally-occurring arsenic is the pentavalent form in the ore, arsenopyrite (FeAsS). The various compounds of arsenic are more relevant for evaluating chronic toxicological effects at the site, since the elemental metallic form is reported to be less toxic than arsenic in compounds (USEPA, 1984a).

Arsenic trioxide (As<sub>2</sub>O<sub>3</sub>), one of the most toxic forms, is a smelter product arising from air roasting of sulfidic ores. Arsenic trioxide has relatively low water solubility. The compound dissolves in acidic or alkaline aqueous media. Arsenic trioxide differs from elemental arsenic in that its vapor pressure is higher.

Natural processes in the environment favor the formation of pentavalent arsenic from trivalent arsenic. Pentavalent arsenic (As<sub>2</sub>O<sub>5</sub>) is much more soluble in water than the



trivalent state. The stability of these two valency forms is dependent on the medium. Oxygenated media and higher pH favor the pentavalent form, while reducing and/or acidic media favor the trivalent form.

Arsenic compounds tend to form in soluble complexes with soils and sediment. In soil, arsenic is usually bound to clay surfaces, and its mobility is a function of several variables, including soil pH, phosphate levels, and iron and aluminum content. The mobility of the pentavalent form is of concern in terms of uptake by plants and migration into surface water and groundwater (USEPA, 1984a).

In the atmosphere, arsenic adheres to particulate matter. In areas near urban and rural areas, arsenic is primarily found in the air in the penta- and trivalent form. Only in agricultural areas or where biotic transformation can occur has arsenic been found in the methylated form.

(iii). Cadmium: The worst-case dose associated with cadmium levels at the site is ten times greater than the AIC for non-carcinogenic effects. Potential carcinogenic effects are also possible via inhalation. The airborne dust concentration resulted in a borderline 10-6, or one-in-a-million, risk on the site. Cadmium concentrations are highest at sample site SS-16, located north of the arsenic kitchens.

The physical/chemical properties and environmental fate and transport characteristics of cadmium have been summarized by Friberg et al. (1986); and references in ATSDR (1987b). Cadmium is a naturally-occurring metallic element that is associated with zinc and lead ores. With a relatively high molecular weight (112), cadmium has a high boiling point and is commonly found in an oxidized state of +2. The solubility of cadmium varies from compound to compound. Cadmium sulfide and oxide are almost insoluble where many of the inorganic compounds are quite soluble in water, e.g., cadmium acetate, chloride, and sulfate.

In the atmosphere, the combustion of coal and petroleum products releases cadmium that is absorbed to small particles (one to two ug/m<sup>3</sup>) in the atmosphere. The particulate matter is transported and can be transferred through the atmosphere to the various environmental compartments via wet or dry deposition.

Cadmium is present in soil as free cadmium compounds or in solution in pore water in soils. It may also be held to soil minerals or organic constituents by cation exchange. The aerobic nature of topsoil tends to reduce the levels of cadmium held as the insoluble sulfide. High soil acidity favors release of Cd<sup>2+</sup> and its uptake by plants.



Cadmium is relatively mobile in the aqueous environment. In natural waters, cadmium may exist as the hydrolated ( $Cd^{2}+ H_{2}O$ ); as metal-organic complexes with  $CO_{3}^{2}-$ ,  $CI_{3}^{2}-$ ; or as metal-inorganic complexes with humic acids. Cadmium is usually found in bottom sediments and suspended particles.

In groundwater, cadmium concentrations are usually low due to sorption by mineral matter and clay, binding by humic substances, precipitation from solution as cadmium sulfide or as calcium carbonate in high alkalinity conditions.

(iv). Chromium: Chromium was flagged as an indicator chemical because its concentration in dust results in a  $5\times10^{-5}$  carcinogenic risk, assuming 100% of the chromium is hexavalent. By the soil ingestion route, chromium was not selected as an indicator chemical because its associated dose was below the EPA criterion for chronic oral intake. Chromium concentrations were elevated in scattered locations of the arsenic plant area, the refinery areas, and the cooling pond (Parametrix et al., 1989).

Native chromium is found only in the ore of chromite (FeCr<sub>2</sub>O<sub>4</sub>), a common constituent of ultra basic rocks and serpentines. Chromium is an insoluble metal with a high melting point. There are two primary valencies of chromium, +3 and +6, the latter being of greatest toxicological concern.

Hexavalent chromium occurs rarely in nature because it is readily reduced in the presence of oxidizable organic matter; however, in water hexavalent chromium is found as chromate and dichromate and is stable due to the low concentrations of reducing agents (ATSDR, 1987c).

Chromium is generally found in the atmosphere in the trivalent state, though in chromate manufacturing areas chromium is also found in the hexavalent form. Chromium is removed from the atmosphere primarily by fallout and precipitation. In the atmosphere, hexavalent chromium may be reduced to trivalent chromium by vanadium, iron, and arsenic.

Since there are no known compounds of chromium that can be volatilized from water, the only passage likely to occur into the atmosphere of chromium is by wind-blown spray. Hexavalent chromium will mainly be in the soluble form but will eventually be reduced to trivalent by organic matter. The bioconcentration factor for hexavalent chromium in fish is one. In bottom-feeding species, such as the blue mussel and softshell clam, the bioconcentration factor may range from 86 - 192 (ATSDR, 1987c).



In soil, chromium is generally found in the trivalent state. It is usually present as insoluble Cr2O3. Flooding of soils followed by anaerobic decomposition of plants may increase the mobility of chromium. The half-life of chromium in soils may be several years (ATSDR, 1987c).

(v). Copper: The highest concentrations of copper were found in the cooling pond area and just north of the arsenic plant and boiler building. The calculated dose of copper at the site exceeded the AIC by approximately one order of magnitude.

Copper commonly occurs in nature and was brought to the site as copper bearing ore. The major sources of copper are chalcocite (Cu<sub>2</sub>S), chalcopyrite (Cu<sub>FeS</sub>), and cuprite (Cu<sub>2</sub>O). Copper is found in elemental +0, +1 and +2 valence states. Most of the +1 valence states are not stable, especially in the presence of water and air, and tend to change to the stable +2 valence state (USEPA, 1984d).

in the atmosphere, copper is present as dust and fumes from smelting and steel industries, as well as from coal-burning plants. The primary reaction in the atmosphere is thought to be speciation, in which copper is converted to copper oxide (USEPA, 1984d). The atmospheric half-life of copper is dependent on particle size and density.

In water, copper is likely to undergo sorption or chemical speciation. In polluted waters, copper may form complexes with organic matter and be adsorbed onto clay material. In organic rich sediment, copper may be redissolved and persist in the water column. The bioconcentration factor for copper varies from 12 for algae to 30,000 for mollusks (USEPA, 1984d).

The fate of copper in the soil may be dependent on the pH, moisture content, and organic matter content of the soil. The mobility of copper increases as the acidity of the soil increases (USEPA, 1984d).

(vi). Lead: The mean soil concentrations of lead found on the site indicated lead is a chemical of potential concern. The worst-case dose was calculated as 0.18 mg/kg/day and is one order of magnitude higher than the acceptable daily intake of 0.001 mg/kg/day. The highest concentrations of lead were in the cottrell area and northeast of the arsenic plant (Figure 1).

Lead is ubiquitous in the environment, in part due to its natural occurrence and its use in gasoline, dyes, paints, batteries, and other common products. Both natural and



anthropogenic deposits of lead in soils generally occur as salts or sulfates, carbonates, sulfides, and phosphates. Nearly all forms of lead are relatively insoluble in water, and are strongly absorbed or precipitated onto both inorganic and organic soil materials. Lead is mobilized within groundwater environments only in the presence of organic chelators or under certain environmental conditions of low pH. Atmospheric lead is typically associated with suspended particulates.

Natural concentrations of lead in the Puget Sound area range from approximately 10 to 60 ppm (dry wt.; Harper-Owes, 1985). Concentrations of lead are considerably greater near roadways, and the average level reported for street dust in residential areas of the Seattle region in 1981 was  $570 \pm 510$  ppm (METRO, 1982). Soil lead levels adjacent to residences may also be elevated (to 1,000 ppm or more) as a result of lead-based paint accumulations (USEPA, 1986a).

Blood lead levels of children have been shown to be correlated with environmental lead levels and magnitude of adverse health effects. The EPA has recently changed the "maximum safe blood level" for pediatric exposures from 30 micrograms of lead per deciliter of blood (ug/dl) to 10-15 ug/dl (USEPA, 1988b).

Blood levels of children have been measured for the Tacoma area in conjunction with investigations of health effects of the smelter. In 1972, blood levels of children from Ruston School near the smelter (14.7 ug/dl) were not significantly higher than blood levels of a control population of children that were not exposed to smelter emissions (15.8 ug/dl; Glass, 1984).

(vii). Mercury: Mercury was brought to the Asarco site as HgS (mercuric sulfide), also known as the mineral cinnabar. Cinnabar is a relatively rare mineral that occurs in recent volcanic rocks and hot springs, and can be a mineral component of copper ore. During the smelting and refining process, the inorganic mercury in the ore can volatilize, oxidize, or form complexes with other metals.

The highest levels of mercury (0.1 to 695 ppm) were detected in surface soil samples in the area of the cottrells, arsenic plant, and related processing areas (Figure 1). This pattern suggests that mercury was trapped in flue dust from the smelter, and was transported from the smelter to the arsenic plant where the arsenic in the dust was reclaimed.

The forms of mercury present at the site have not been identified. Inorganic and possibly some elemental mercury are the more likely forms of mercury at the site given that the source appears to be mainly flue dust from the smelter. Smaller amounts of organic forms



of mercury are also possible due to methylation by anaerobic bacteria in soil. This process is likely to proceed in soils compared to sediments (USEPA, 1984e). If one assumes that all mercury present in site soils is inorganic mercury, the allowable dose under the "worst-case" assumptions of the indicator screen is exceeded by a factor of two at present site concentrations. Under the unlikely assumption that all of the mercury present in site soils is in the organic form of methylmercury, the acceptable dose for methylmercury is exceeded by an order of magnitude.

Mercury is found in three oxidation states: 0 (metallic), 1+ (mercurous) and 2+ (mercuric) mercury. Elemental or metallic mercury has a high atomic weight (200.6). At room temperature, it is the only metal which exists in a liquid form and is rather volatile with a vapor pressure of 0.0012 mm Hg (USEPA, 1984e). In soils and in surface waters, mercury exists in the mercurous and mercuric states as a number of compounds.

Mercury is interconverted among the different forms in the environment (Berlin, 1986). Metallic mercury can be oxidized to inorganic divalent mercury or methylated in sediments (Goyer, 1986). This process usually results by the action of anaerobic bacteria, especially in sediments (USEPA, 1984g). Methylmercury is readily taken up and accumulated by organisms. In aqueous environments, mercury can adsorb onto particulate matter and be transported in the water column. It can also be removed from the water column by becoming incorporated into sediments. In soils, the mobility and leaching of mercury has been described as minimal because mercury compounds bind strongly to organic matter (USEPA,1984 e,g)

(viii). Nickel: This metal was conservatively selected as an indicator chemical because the concentrations of nickel in dust both on and off site resulted in 10-6, or one-in-a-million cancer risk via inhalation. Although this risk is at the screen risk level, the carcinogenic risk of this chemical adds to the overall site risk. Nickel is of much greater concern by the inhalation route than by the ingestion route of exposure. Nickel was not selected as being of potential concern via ingestion; the worst-case dose resulting from nickel would be an order of magnitude less than the AIC. The highest concentrations of nickel in soil were found at SS-16, an area between the arsenic kitchens and the storage bins.

The environmental fate and transport characteristics of nickel have been summarized by Norseth (1986) and references in ATSDR (1987d). Nickel is a metallic element whose primary ore is pentlandite. Metallic nickel is insoluble and has a very high melting point. As with most metals, the physical characteristics vary from compound to compound. Nickel subsulfide and nickel oxide have low solubility, whereas nickel chloride and nickel sulfate are soluble in water and very soluble in alcohol.



The primary source of nickel in the atmosphere is from the pyrolysis of fuel oil. In the atmosphere, nickel exists primarily as an aerosol. Nickel species present in the atmosphere include soil minerals, oxides, and sulfates. The primary removal of metal for the atmosphere is by wet and dry deposition.

The persistence of nickel in aquatic media ranges from 23,000 years in the deep ocean to 19 years in near-shore coastal water. The solubility of nickel is dependent on the chemical and physical properties of the water. In organo-rich polluted water, nickel will exist as inorganic salts and organic complexes. In anaerobic environments, nickel will be found as nickel sulfide. Nickel is significantly bioaccumulated in some aquatic organisms. Typical values are as follows: freshwater fish, 40; freshwater plants, 100; algae, 2,000-40,000.

Nickel ferrite (NiFe<sub>2</sub>O<sub>4</sub>) is the most probable nickel species to precipitate in soil. Nickel is reasonably mobile in low pH conditions, but less mobile in basic mineral soils and soil with high organic content. Nickel in dump sites will have higher mobility in acidic rain.

## b. Organic Chemicals

The organic chemicals selected as indicator chemicals by the ingestion route include PCBs and polycyclic aromatic hydrocarbons (PAHs). All carcinogenic chemicals that were detected but not selected resulted in risks that were at least an order of magnitude less than 10-6. These chemicals were not found to have significant non-carcinogenic effects at the levels present at the site, and therefore would have a far less contribution to the overall site risk than the other carcinogenic metals and organic chemicals that were selected. Detection limits for organic chemicals that were not detected in any sample were found in most cases to be adequately low enough to be protective of public health. Exceptions were benzidine and N-nitrosodimethylamine which were not detected in any sample but had detection limits that were not sufficiently low to determine whether they are present at levels of potential concern. These chemicals were not selected as indicator chemicals for the reasons discussed in the section following the individual discussions of the indicator chemicals.

In addition, dibenzofuran, dibenzothiophene, and m-nitroaniline were detected in a few samples at the site, but could not be evaluated quantitatively in this report because of a lack of physical and toxicological data on these chemicals. However, sufficient toxicological information was available for a qualitative analysis of dibenzofuran and m-nitroaniline. (Section IV; Toxicity Assessment).



(i). Dibenzofuran: Dibenzofuran (mean = 0.54 ppm; upper 95 percentile of samples = 2.58 ppm) was detected in 18% of samples, primarily near the arsenic production and copper smelting areas. Some polychlorinated dibenzofurans are known carcinogens (mainly three isomers); however, the type detected at the site is reported to be unchlorinated dibenzofuran (Lancaster Laboratories, 1988; Parametrix et al., 1989) with little available data on their health effects. The health risks of this chemical are therefore discussed qualitatively in this report.

Dibenzofuran is a white crystalline solid which is used in industry to manufacture perfumes and soaps, as heat-transfer medium resins for laminated electrical insulation, and as chemical intermediates for halogenation and other reactions (Sax and Lewis, 1987). They are also released by combustion of coal tar, refuse, and diesel fuel.

The physical properties of chlorinated dibenzofurans are similar to polychlorinated biphenyls (see below) and polychlorinated dibenzodioxins. These compounds have low solubilities, low vapor pressure, high boiling points, strong adsorption to soils, and high bioaccumulation (WDOE, 1985). The solubility, bioaccumulation, and chemical inertness of these compounds generally decreases with decreasing chlorination. Dibenzofuran has been shown to be biodegraded readily by adapted microbes in oxygenated screening tests (HSDB, 1988).

(ii). Dibenzothiophene: This chemical was detected in 12% of samples (mean = 0.41 ppm; upper 95 percentile of samples = 1.60 ppm). It is localized to a few locations in the site stabilization area. This compound is identical in structure to dibenzofuran except that dibenzothiophene has a sulfur substituted for the oxygen on the middle five carbon ring. It is a colorless crystalline solid which is found in coal and shale oils and is used in cosmetics and pharmaceuticals, and as a chemical intermediate (Sax and Lewis, 1987). Little quantitative toxicological information could be found on dibenzothiophene. Because of the similarity in structure and composition of dibenzothiophene and dibenzofuran, one would expect similarity in physical chemical properties. It is reported to inhibit photosynthesis of algae at high concentrations (Verschueren, 1983).

(iii). HPAHs: The high-molecular-weight PAHs (HPAHs) were selected as indicator chemicals because the total concentration of HPAHs in soil resulted in a carcinogenic risk that was 10-3, or three orders of magnitude above 10-6, assuming that all HPAHs were the same toxicity as benzo[a]pyrene, which is a very conservative assumption. These compounds appear to be localized in certain areas rather than widespread at all sampling locations. The highest concentrations of HPAH were found at SS-21, about 100 feet south of the storage bins in the stabilization area.



HPAHs are some of the most chronically toxic components of hydrocarbon mixtures which also include alkanes, alkenes, cycloalkanes, and other aromatic hydrocarbons in varying proportions; nitrogen, sulfur, and oxygen-containing compounds are present in much smaller amounts (USEPA, 1981b). The chronic toxicity of alkanes, alkenes, and cycloalkanes is generally quite low with a few exceptions (Sandmeyer, 1981a,b; see Appendix D). Among the aromatic hydrocarbons found in petroleum products, the greatest carcinogenic hazard is associated with benzene and other polycyclic aromatic hydrocarbons (PAHs) that are carcinogenic. The carcinogenic PAHs are mainly the higher molecular weight compounds (HPAHs) composed of four or more aromatic rings.

The HPAHs in the highest concentrations at the site, pyrene and fluoranthene, have not been found to be carcinogenic in humans or laboratory animals (IARC, 1983). In addition, benzo[a]pyrene represents less than 9% of the total amount of HPAHs, although the total amount of HPAHs is evaluated as 100% benzo[a]pyrene (B[a]P) to follow conservative EPA guidelines (USEPA, 1984f). This chemical is the most researched PAH and is considered the most carcinogenic. The HPAHs and low-molecular-weight PAHs (LPAHs) measured at the site and their associated evidence for carcinogenicity in animals according to IARC (1983) are as follows:

<u>HPAHs</u>	Evidence in Animals	Mean (ppm)
Benz[a]anthracene	1	4.44
Benzo[b]fluoranthene	1	4.81
Benzo[k]fluoranthene	1	0.25
Benzolg,h,ilperylene	3	2.04
Benzolalpyrene	1	3.59
Chrysene	2	4.85
Dibenzo[a,h]anthracene	1	0.52
Fluoranthene	4	8.41
Indeno[1,2,3-cd]pyrene	1	1.72
Pyrene	4	10.96



<u>LPAHs</u>	Evidence in Animals	Mean (ppm)
Anthracene	4	1.86
2-Methylnaphthalene	<b>3</b>	1.08
Acenaphthylene	3	0.25
Fluorene-	3	1.42
Naphthalene	4	2.06
Methylphenanthrene	4	0.61
Phenanthrene	3	9.57
2-Chloronaphthalene	3	0.20

where 1 = sufficient evidence of carcinogenicity, 2 = limited evidence of carcinogenicity, 3 = evidence inadequate to permit an evaluation of carcinogenicity, and 4 = no evidence of carcinogenicity.

PAHs are a class of compounds that are formed during the incomplete combustion or pyrolysis of materials containing hydrogen and carbon. They also occur naturally in fossil fuels. Of this class, B[a]P is the most researched species. In the atmosphere, it is believed that B[a]P exists primarily in the particulate sorbed phase. B[a]P has a low water solubility and is a highly lipophilic (soluble in organic solvents or fats). As a result, these types of chemicals would be expected to bioaccumulate in fatty tissues of organisms. The primary mechanism for the removal of PAHs in soil is by microbial degradation. The half-life of PAHs in soil ranges from less than one day to a few years (USEPA, 1984f). Because of their high soil sorption coefficient and low water solubility, these compounds are expected to have low mobility in soils. Significant leaching into groundwater is therefore not expected, especially from soils with high organic carbon content (USEPA, 1984f).

(iv). m-Nitroaniline: m-Nitroaniline was detected in 5% of the samples with a mean of 1.24 ppm and an upper 95% level of 1.41 ppm (detection limit = 1.00 ppm). It was selected as an indicator chemical for a qualitative risk evaluation because of the limit quantitative dose-response information available on the toxicology of this chemical.

m-Nitroaniline is a yellow crystalline solid used as a dyestuff intermediate which forms water-soluble salts with mineral acids (Merck, 1988). Degradation of m-Nitroaniline by soil microbes is reported to require over 64 days (Verschueren, 1983).



(v). PCBs: PCBs were also selected as indicator chemicals because the soil concentration resulted in a carcinogenic risk that was 10<sup>-5</sup>. PCBs were detected in a few locations with the highest level of PCBs located at SS-33 near the cottrell powerhouse (Figure 1).

The physical properties of PCBs are well known and have been summarized in several reports, including USEPA (1980b) and Sawhney (1986). PCBs are highly stable compounds having a low dielectric constant and high heat capacity. These properties make them ideal for use in electrical capacitors and transformers, but also render them highly persistent in the environment. PCBs generally have low water solubility and low rates of vaporization, although results of mathematical models indicate that inhalation exposure may be significant under certain conditions (USEPA, 1986b).

The environmental fate and transport of PCBs are largely determined by the very low water solubility and corresponding high organic solubility of this chemical class. PCBs bind strongly to organic matter in soils, so that leachability is inversely related to organic and clay content in soils (USEPA, 1980b). Horizontal leaching is reported to be minimal, particularly in clay soils. Vertical leaching has been shown to extend less than nine inches (WDOE, 1985).

(vi). Non-detected chemicals with high detection limits: Because of the high detection limit of benzidine relative to its toxicity (<3.0 ppm), the associated risk was three orders of magnitude greater than 10<sup>-6</sup>. Benzidine has no history of use on the site. Therefore, this compound was not selected as an indicator chemical.

Benzidine is used primarily in the production of azo dyes and polyurethane production. It is thought to be commonly distributed in the environment (ORNL, 1978). Benzidine is thought to be volatile and soluble enough to have a potential for wide dispersion. In water, it is primarily a hazard associated with discharges from dye and pigment factories. The main chemical reaction of benzidine in air and water is oxidative degradation.

Although N-nitrosodimethylamine (NDMA) was not detected in any of the soil samples taken from the site, the detection limit of this chemical was not low enough to determine whether this chemical is present at levels of concern. The mean soil concentration was calculated using the half of the detection limit. This hypothetical concentration resulted in a worst-case risk that was 10-5, one order of magnitude higher than 10-6, which may significantly overstate the actual risk of NDMA. Therefore, this chemical was also not selected as an indicator chemical for further evaluation, because of insufficient evidence of its presence at the site and because the carcinogenic risk of half the detection limit is within the target risk range recommended by EPA (10-4 to 10-7).



Prior to 1976, NDMA was used in the U.S. as an intermediate in the production of certain rocket fuels. It exists as a yellow, oily liquid and has a relative low boiling point. NDMA is soluble in water, organics, and lipids. The stability of NDMA is dependent on the alkalinity of the storage solution. NDMA in alkaline solutions in the dark is stable at room temperatures for more than 14 days, and slightly less stable in acidic solutions. There are little data regarding the environmental fate and transport of NDMA (IARC, 1978).



#### III. EXPOSURE ASSESSMENT

In this section, each source, pathway, receptor, and route of exposure to each indicator chemical is evaluated and compiled in order to assess total human exposure to substances of concern. This step identifies populations exposed to toxic chemicals, and determines the routes, magnitudes, frequencies and durations of exposure. The following characteristics are evaluated:

- o physical and chemical properties
- environmental fate and transport
- o characterization of populations at risk
- o chemical concentrations at exposure points

This report follows recent EPA recommendations by calculating exposure for target populations under "typical" as well as "worst-case" (upper bound) conditions. Worst-case exposure incorporates a number of conservative assumptions in determining chemical intake rates and characteristics of the receptor population. Worst-case exposure is thus the maximum exposure possible at the site and is likely to overestimate the actual risk significantly. Calculations of typical exposure allow the resulting risks to be more realistically evaluated for the site.

The result of this section is a calculated daily dose of each indicator chemical per body; weight due to exposure to chemicals in soil. This dose is calculated independently for each route of exposure and each population at risk. Figure 2 illustrates the various pathways and routes of exposure to chemicals at the site. Results are compiled in Section F on calculation of the dose.

#### A. EXPOSURE SCENARIOS

Three exposure scenarios are considered, including different land uses of the property and offsite exposure. These land uses are considered separately, that is, the site is assumed to be developed as a residential community or as an industrial complex, but not a combination of the two.

#### 1. Onsite Residential

This scenario assumes that the plant buildings are torn down and the site is redeveloped into a residential area but that no soils are removed from the site. Exposure is evaluated for hypothetical residents who spend an entire lifetime continually exposed to the areas of

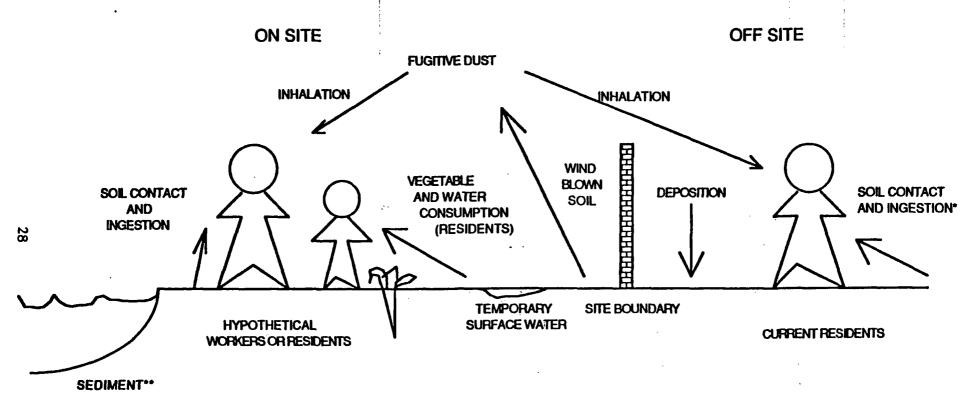


FIGURE 2: MAIN EXPOSURE PATHWAYS OF CONCERN AND POPULATIONS AT RISK FOR CONTAMINANTS IN SOIL

SEE ALSO THE FOLLOWING FOR DISCUSSION OF THESE PATHWAYS:

- \* BLACK AND VEATCH (1988)
- •• TETRA TECH (1988).



average to maximum contamination on the site. Pathways of primary concern include ingestion of chemicals in soil or in vegetables grown on site, inhalation of metals in dust, and dermal absorption of chemicals in soil. The possibility of exposure to surface water is also considered.

#### 2. Onsite Industrial

This scenario assumes that the site is developed for industrial or commercial use with similar soil conditions to the onsite residential scenario. Pathways of concern for workers under this scenario are the same as for residents except that workers do not grow and consume vegetables at the site. Risks are evaluated for a 40-year period of continuous employment at the site, five days a week, 10 hours a day.

#### 3. Offsite Residential --

This study supplements the previous evaluation of exposure to offsite residents (Black and Veatch, 1988) by more accurately assessing exposure under current conditions due to inhalation and deposition of metals in fugitive dust. The exposure route of primary concern for this scenario is thus the inhalation of resuspended dust from the site. In addition, changes in the risk estimates of Black and Veatch (1988) for soil ingestion exposure due to deposition and accumulation of arsenic in soils are evaluated.

The main focus is on residents living at the location of highest offsite impacts from metals in fugitive dust. As recommended by USEPA (1988c), it is assumed that exposure conditions for this population are equal to current offsite conditions. Because the property is currently fenced, no onsite exposure is considered. If nearby residents did have access to the site, the magnitude of their exposure would be intermediate between the current estimated offsite exposure and that experienced by hypothetical residents of the site.

#### B. ROUTES AND PATHWAYS OF EXPOSURE

This section identifies the possible pathways of concern for the various exposure scenarios considered. Some pathways of exposure are excluded by this process because they were determined to be of relatively minor health concern in comparison to the other pathways, or because they have been evaluated by other reports. Table III-A summarizes the relevant routes of exposure for the indicator chemicals.





# ROUTES OF CONCERN FOR INDICATOR CHEMICALS

CHEMICAL	ROUTE OF CONCERN
Metals	
Antimony	oral
Arsenic	oral, inhalation
Cadmium	oral, inhalation
Chromium VI	inhalation
Copper	oral
Lead	oral, inhalation
Mercury	oral, inhalation, dermala
Nickel	inhalation
Organics	
Dibenzofuranb	oral, dermal
Dibenzothiopheneb	oral, dermal
HPAHs	oral, dermal
m-Nitroaniline <sup>b</sup>	oral, dermal
PCBs	oral, dermal
•	

<sup>Dermal absorption was considered negligible relative to the other pathways of exposure (USEPA, 1984g).
Available data are insufficient to evaluate risks quantitatively</sup> 



# 1. Ingestion of Soil

Ingestion of soil or dust is a primary route of exposure to chemicals in soil. Children are more likely to ingest soil during outdoor play and to ingest dust during indoor activities than adults because of their more frequent hand-to-mouth behavior. Adults may also ingest small amounts of soil during gardening or while caring for pets. Construction workers who are involved in moving earth are the most likely group to ingest soil occupationally.

The extent of systemic absorption of chemicals should be accounted for in assessing exposure by a given route if absorption is likely to be different for the populations at risk compared to the population (human or laboratory animals) used to develop the relevant toxicity criteria. Such differences between populations may result from differences in the administered form of the toxicant, or from differences in physiological processes. Absorption of all ingested indicator chemicals was assumed to be 100% except for chemicals for which the literature clearly indicated otherwise. These exceptions are described below.

For lead, the EPA criterion is based on studies of ingestion of lead in drinking water (USEPA, 1980a). This form of lead is expected to result in higher absorption than would result from ingestion of lead in soil, as is assumed to occur at this site. We therefore developed an estimate of relative percent absorption from soil versus water. Goyer (1986) reports that absorption of ingested lead is 5 to 15% in adults with a retention of less than 5% of the absorbed amount. In infants, 41.5% is absorbed with a net retention of 31.8%. People with certain nutritional deficiencies, however, can absorb and retain lead to a greater extent than normal (Goyer, 1986). We made the conservative assumption that the absorption and retention rates for children and adults were equal to the infant absorption rate of 42%.

Absorption of ingested arsenic varies greatly with the water solubility of the arsenic compound and the physical form administered (USEPA, 1984a). For example, absorption of arsenic trioxide is reported to be 30 to 40% for the compound in suspension, but as high as 95% and greater for the compound in solution. The toxicity criterion is based on the more soluble form, pentavalent arsenic, dissolved in drinking water. The types of arsenic produced at the site are metallic arsenic and arsenic trioxide, although some of the arsenic trioxide may have been oxidized to arsenic pentoxide. Nevertheless, because ingested arsenic in site soils is more comparable to arsenic in a suspension than to arsenic in a solution, 40% absorption was assumed in the exposure assessment for ingestion of arsenic

in soil. Absorption of arsenic in home-grown vegetables, however, was assumed to be 100% because the metal is likely to be more readily absorbed in food (Goyer, 1986).

Absorption by humans of ingested PCBs in soil is estimated to be 30% relative to absorption of the pure product or of PCBs in a corn oil medium administered to laboratory animals (USEPA, 1986b). The absorption of lipophilic chemicals (such as PCBs) in the GI tract is reduced by the tendency of these compounds to adsorb strongly to organic matter in soil (Hawley, 1985).

HPAHs are another type of highly lipophilic compound for which adsorption onto organic matter in soil is expected to decrease the availability of PAHs in the gastrointestinal (GI) tract. The absorption of PAHs has been summarized by USEPA (1984b,e). Absorption of HPAHs is reported to be decreased by the hydrophilic nature of the mucous layer lining the GI tract. Approximately 50% of orally administered B[a]P is reportedly absorbed by rats. In mice, however, B[a]P is reported to readily penetrate the forestomach epithelium regardless of the type of vehicle used to administer the B[a]P. By contrast in the glandular stomach, the absorption of B[a]P is decisively affected by the type of solvent vehicle. Absorption is increased by hydrophilic solvents relative to lipophilic solvents.

Because the stomach of humans is mainly glandular without a developed forestomach, adsorption of PAHs onto organic matter in soil is expected to reduce the availability of PAHs by the oral route. The EPA criterion for evaluating PAH toxicity by this route, however, is based on the incidence of stomach tumors in mice (USEPA, 1984f). Therefore, because of the differences in the stomachs of humans and mice, we assumed that absorption of HPAHs would be reduced by 50% in humans relative to mice.

Table III-B lists the relative percentage absorption assumed for the indicator chemicals by the oral route of exposure. Nickel and chromium are not included because these chemicals were below worst-case screening levels for the ingestion route; they were selected based on their carcinogenic effects via inhalation.

#### 2. Ingestion of Vegetables Grown at the Site

Another possible source of exposure is ingestion of home-grown vegetables that take up chemicals in soil. Although this pathway is not included in the EPA guidelines for a baseline health evaluation (USEPA, 1986c), exposure via this pathway was examined for the indicator chemicals because some, such as cadmium, are reported to accumulate in crops (USEPA, 1981a) and are thus a potential source of exposure to chemicals in soil.



# TABLE III-B PERCENT ABSORPTION ASSUMED BY ROUTE OF EXPOSURE

CHEMICAL	ROU			
	Ingestion	Inhalation	Dermal	,
Metals				
Antimony	100.	100.	0.b	
Arsenic	100.	30.ª	0.b	
Cadmium	100.	100.	0.ь	
Chromium	100.	100.	0.b	
Copper	100.	100.	О.Ъ	
Lead	<b>42</b> .c	100.	0.ь	
Mercury	100.	100.	O.q	
Nickel	100.	100.	0.ъ	
Organics		·		
НРАН	50.e	, <del></del>	6.f	
PCB	30.g	•	1.g	

<sup>--</sup> Organic chemicals are not evaluated by the inhalation route (see Section B4.)

a USEPA (1984a)

<sup>&</sup>lt;sup>b</sup> ACGIH (1986)

c Goyer (1986)

d Dermal absorption was considered to be negligible relative to other routes of exposure (USEPA, 1984g)

d USEPA (1984f)

e Heidelberger and Weiss (1951); Poiger and Schlatter (1980)

f USEPA (1986b)



Data on soil and corresponding vegetable concentrations were readily available for several of the metals of concern. The uptake of chemicals (especially metals) by plants has been studied as a part of research on the environmental and health effects of contaminants in sludge (USEPA, 1981a; USEPA 1985a,b,c,d,e) and of products of mining and smelter emissions (Alloway and Morgan, 1986; Thornton, 1986). Quantitative data that would permit a similar evaluation for the organic chemicals of concern were unavailable, and therefore, this pathway could not be assessed for the organic chemicals.

Ingestion of home-grown livestock is unlikely at this site because of the urban nature of the area. As a result, the analysis of exposure via home agriculture was limited to produce.

### a. Factors Influencing Uptake of Metals by Plants

Although the soil concentration has been found to be the major determinant of metal uptake by plants, several other factors also have an influence. Plant properties such as type of species and genetic strain, as well as the time of the year, all affect the accumulation of metals in plant tissues (USEPA, 1981a; USEPA, 1985a,b,c,d,e). In addition, different parts of plants accumulate metals in different concentrations. Vegetative parts (e.g., stems and leaves) generally contain higher levels of metals than do grain, fruit, or tubers (e.g., potatoes). Leafy vegetables (especially chard) seem to concentrate metals to a greater degree than other crops (Sikora et al., 1980; USEPA, 1981a; USEPA, 1985a,b,c,d,e; Cappon, 1987).

Soil pH and buffering capacity affect the partitioning of metals between the soil solution and the solid phase, thereby influencing metal absorption by plants (USEPA, 1981a; Petruzzelli et al., 1987). Lower pH generally increases the solubility and uptake of many metals (Sikora et al., 1980), although it also decreases plant growth as well. The buffering capacity or cation exchange capacity of the soil has complex effects on the ionic state of metals which affect their solubility (USEPA, 1981a; Alloway and Morgan, 1986). Cation exchange capacity is a function of the amount of organic matter, clay content, and minerals in soil as well as the type of nitrogen, phosphorous, and potassium compounds added as fertilizers.

The uptake of a given metal by plants may also be influenced by the types of other metals present in the soil (USEPA, 1981a). Metals can compete for sorption sites in the soil, and for uptake by plants or translocation within plants. The presence of other metals may also cause toxic effects in plants, thereby affecting growth and accumulation.



A major assumption of this report is that the soils and forms of metals at the site are similar to those examined in research on uptake of metals by plants. We assume that metal uptake by plants at the smelter site is similar to that reported in the literature for other soils because of (1) the difficulty of predicting the specific effects of soil properties on uptake, and (2) the relatively minor importance of soil properties compared to other factors such as metal concentration and type of crop. Wherever possible we used plant uptake data obtained from soils affected by inorganic pollution sources such as smelters rather than data from soils treated with sewage sludge containing heavy metals.

Heavy-metal accumulation in soil and vegetation from smelter emissions from the Tacoma Plant was studied in the early 70's before the addition of air pollution control devices (USEPA, 1974). During this period, sulfur dioxide production at the plant acidified surrounding soils. The limited data set for garden vegetables presented by USEPA (1974) indicates that uptake of arsenic, cadmium, and lead by vegetables was higher than normal for vegetables grown near smelters (Thornton, 1986). A decade later, with air pollution control devices added to control sulfur dioxide emissions, concentrations of arsenic in vegetables measured as a part of the 1987 pathways study (Polissar, 1987) were within the range reported for uncontaminated vegetables. The data from the 1974 study were judged to be inappropriate for the present assessment of uptake of metals in vegetables because of sampling inadequacies and the difference in soil pH attributable to SO2 emissions.

#### b. Determination of Metal Uptake by Crops

Plant uptake of cadmium from soil is relatively more efficient than uptake of the other indicator metals (USEPA, 1981a; USEPA, 1985a,b,c,d,e; Alloway and Morgan, 1986; Thornton, 1986). Common garden crops have also been shown to take up arsenic, lead, and copper from soil. Data on the uptake of antimony by plants were not readily available in the literature, but uptake is expected to be relatively low because of the low solubility of antimony compounds (USEPA, 1985f). The other metals of concern at the site, nickel and chromium, were selected as indicator chemicals based on their inhalation hazards but were not of concern by the ingestion route. These chemicals are not evaluated for the vegetable ingestion pathway.

The garden vegetables used in this assessment were selected on the basis of available data and the probability that they would be grown in gardens in the Ruston area. The categories selected were leafy vegetables and root vegetables, which have been slow to concentrate metals to a greater degree than grain fruit or tubers (USEPA, 1981a, USEPA, 1985a,b,c,d,e).

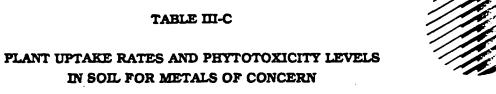
To calculate accumulation by vegetables for each metal, a root uptake factor from soil was determined for representative vegetables. This factor is the slope of a linear regression of the concentration of a metal in vegetables on the corresponding concentration of the metal in soil. This factor was multiplied by the concentration of a metal in the soil at the site to estimate the amount available in home-grown produce (see Section III. D., Exposure Concentrations, below).

The accumulation of metals by home-grown vegetables is ultimately limited by the threshold concentration of metal phytotoxicity. In other words, at some concentration of metals in soils, conditions become toxic enough to inhibit plant growth or survival. At this point, the vegetable ingestion pathway is no longer of concern. Exposure to metals via the home-grown produce pathways was thus considered unlikely above the upper limit for soil concentrations of each indicator metal for a given crop yield. We assumed the relevant soil concentration for possible exposure to home-grown produce to be the soil concentration that would decrease crop yield and growth by 90 to 100% in most plants, and by no less than 50% in a few plants. Soil concentrations above this level would greatly reduce home-grown vegetable consumption and hence the likelihood of exposure to metals by this pathway. Table III-C presents the uptake factors used for leafy and root vegetables and the threshold levels for phytotoxicity.

(i). Arsenic: Plant uptake of arsenic from soils with elevated concentrations due to mining or smelting activities has been summarized by Thornton (1986). The ratios of plant concentration to soil concentration are approximately 0.01 and 0.001 for leafy and root vegetables, respectively (i.e., plant concentration = soil concentration X 0.01 or 0.001).

Soil arsenic concentrations of 40 to 100 ppm have been reported to cause a 50% or greater reduction in plant growth and yield. (USEPA, 1985a). Consequently, we assumed conservatively a threshold soil concentration of 100 mg/kg as the upper limit for exposure via home-grown vegetable yield in site soils, because plants could not be grown where soil concentrations exceed 100 ppm arsenic.

- (ii). Cadmium: Cadmium accumulation has been studied extensively in research on the uptake of metals in crops from sewage sludge applied to soils (USEPA, 1985b). Plant uptake factors were averaged for leafy vegetables (lettuce, Swiss chard, turnip greens) and for root vegetables (carrots and radishes). Based on data presented by USEPA (1985b), the phytotoxicity threshold soil concentration assumed for cadmium is 200 mg/kg.
- (iii). Copper: The limited data available on uptake of copper by plants have been summarized by USEPA (1985c) for plants grown in soil treated with sludge. The uptake



METALS	UPTAKE (g soil/g	· ·	PHYTOTOXICITY (mg/kg)
	Leafy	Root	
Arsenic	0.0026ª	0.0006a	100b
Cadmium	1.04c	1.18c	200°
Copper	0.12d	0.01d	1,0004
Lead	0.0052ª	0.0052a	none assumed
Mercury	0.178°	0.0763°	10°

a Thorton (1986)

b USEPA (1985a)

c USEPA (1985b)

d USEPA (1985c)

e USEPA (1985e); Cappon (1987)

rate for leafy vegetables was averaged from data on cabbage, lettuce, and turnip greens. We used potato uptake rates to approximate copper uptake in root vegetables. The highest tolerated soil concentration of copper reported in phytotoxicity tests is 492 ppm. At this concentration, a 50% yield reduction occurred in most crops, although in one case a 5% yield reduction was reported. In this assessment the threshold for phytotoxicity was assumed to be approximately twice the 50% reduction level, or 1,000 ppm.

(iv). Lead: Data presented by Thornton (1986) from urban gardens was used to derive an uptake factor for leafy and root vegetables by calculating the slope of a linear regression of the concentration of lead in vegetables on the concentration of lead in soil. This slope was similar for both lettuce and radishes (slope = 0.005 g soil/g vegetable, r > 95.0). Lead levels that are high enough to prohibit vegetable grow in soil are in the range of 1,000 ppm or greater (USEPA, 1985d). Therefore, given that lead levels at the site are generally on the order of 1,000 ppm, we assumed no upper limit for home-grown vegetable production. This is a conservative assumption because vegetable growth may be further limited by concomitant levels of more phytotoxic metals such as arsenic.

(iv). Mercury: Mercury uptake by plants is affected by the chemical form of mercury and by such soil characteristics as organic matter content and pH. Methylmercury is reported to be taken up more readily than inorganic mercury. Because of the possibility that methylmercury may be present at the site as a result of action by soil bacteria, plant uptake rates for inorganic and methylmercury were averaged in estimating uptake ratios for leafy and root vegetables (Table III-C; USEPA, 1985e; Cappon, 1987).

The available data suggest that mercury is more toxic to plants than are the other metals of concern. Concentrations of 0.03 to 1.00 mg/kg caused reductions in growth of 56.6% to 79.4% in corn, beans, and tomato seedlings growing in nutrient solutions (USEPA, 1985e). By comparison, concentrations of 8 mg/kg limited growth and 50 mg/kg was toxic to bermuda grass (USEPA, 1985e). Because the toxic effects of mercury concentrations in solutions are not thought to be equivalent to the effects from mercury concentrations in soil (USEPA, 1985e), 50 mg/kg was selected as the phytoxicity level for the site.

#### 3. Exposure to Water

The groundwater of the site is evaluated in Volume 1 of the Remedial Investigation report. Chemicals in groundwater are presently not considered a pathway of exposure for risk characterization since groundwater on the property is not a source of drinking water. Site proximity to Commencement Bay may also limit the use of this water. Environmental threats to aquatic organisms and exposure to chemicals from the site in the adjacent bay

via ingestion of fish are being evaluated independently by the Commencement Bay report (Tetra Tech, 1988) and by aquatic toxicity tests reported in Volume 1 of the Ri report. These efforts will not be duplicated here.

The other source of surface water currently at the site is the cooling pond (Figure 1). Standing water can accumulate in this depression during winter months. When viewed in summer, little water was present and vegetation grew in the center. This area is currently surrounded by a cyclone fence. Hypothetical onsite residents could have access to the pond, assuming that the fence were removed and the depression were not filled in. The water would be present in the cooler months when children are less likely to play in water.

Water quality samples were not available from this pond. The available soil sample data include ten samples from around the edges of this pond and five samples from sediments in the pond. Levels of the chemicals of concern in this area were generally lower than average for the property. Levels of arsenic in sediments (1,468. ppm), for example, were approximately an order of magnitude less than the average arsenic concentration on the site. An exception is copper for which the average concentration near the pond (48,714 ppm) and in sediments (16,213 ppm) exceeded the average on the property (11,457 ppm). Depending on the solubility of the form of copper present, additional exposure to copper during recreation at the cooling pond may be possible, although exposure to this water would be relatively infrequent during cooler months of the year and impossible during warmer seasons when the pond is dry.

Other possible surface water exposure may occur shortly after heavy rainfall when puddles of water may form on the site. The most likely exposure would be acute exposure to young children playing in this water. Therefore, health effects via such exposure were screened by evaluating the potential effects of ingestion of 100 ml of surface water runoff by young children (10 kg body weight). Because children playing in puddles would most likely be exposed to turbid water, data for total metals were used rather than dissolved metals. Average and upper 95% concentrations of metals were calculated from Round 2 data on surface water runoff on site during three storm events (Volume 1, RI report). These concentrations and the estimated typical and worst-case doses to children (see Table III-D) were compared with various health criteria as outlined below.

Of the eight metals of concern, nickel and cadmium are the only two that have established EPA Health Advisories (HA) for water. Both the average and upper 95% site concentrations of nickel are an order of magnitude less than the short-term HAs (USEPA, 1987a). Though the average concentration of cadmium is less than the short-term HAs, the upper 95% concentration for cadmium is approximately four times the One- and Ten-Day HAs (USEPA,





# CONCENTRATION OF METALS IN SURFACE WATER RUNOFF AND ACUTE EXPOSURE ESTIMATES FOR CHILDREN

	ESTIMATED		ESTIMATED		
METAL	CONC. IN			E DOSE	
	WATER RUN	OFF (ppm)	(ug/)	kg/day)	
·	Mean	Upper 95%	Typical	Worst-Case	
Antimony	0.09	0.33	0.9	3.3	
Arsenic	1.03	4.12	10.3ª	41.2	
Cadmium	0.03ь	0.18	0.3	1.8	
Copper	2.6	12.09	26.0°	120.9	
Lead	0.27	0.95	2.7 <sup>d</sup>	9.5 <sup>d</sup>	
Mercury	1.2e	4.5°	0.01	0.05	
Nickel.	0.04b	0.12b	0.4	1.2	
Zinc	1.54	9.73	15.4°	97.3c	

NOTE: Typical Dose = (average water concentration • 0.1 liters/day)/10 kg
Worst-Case Dose = (upper 95% concentration • 0.1 liters/day)/10 kg

<sup>\*</sup> Equal to No Observed Adverse Effect Level for humans (ATSDR, 1987a)

b Below One- and Ten-Day Health Advisories for children (USEPA, 1987a)

c Below Acceptable Intake for Chronic Exposures (AIC) (USEPA, 1986c)

d Below Lowest Observed Adverse Effect Level for humans (ATSDR, 1988)

e Below Minimum Risk Level for Short-Term Exposure (ATSDR, 1989). Measurements in ppb.

1987a). This difference should not be of toxicological significance, however, as the HAs were developed using chronic drinking water intake rates which are higher and assumed to occur over a longer period than for the acute exposure evaluated for children playing in temporary puddles on site.

The estimated worst-case dose of lead is approximately one-half the Lowest Observed Adverse Effect Level (LOAEL) for humans based on studies of acute exposure (ATSDR, 1988). For mercury, the concentration in surface water runoff was more than two orders of magnitude below the Minimal Risk Level for Short-Term Exposure reported by the Agency for Toxic Substances and Disease Registry (1989).

Acute exposure criteria relevant to water ingestion were not available for the other metals, so criteria based on chronic exposure were used for comparison, although chronic exposure is unlikely to occur. This is a conservative assumption which will significantly over-state risks. The estimated typical dose of arsenic was found to equal the No Observed Adverse Effect Level for chronic human exposure (ATSDR, 1987a). Although gastrointestinal distress, neuritis, and/or skin lesions have been reported in humans exposed for a long period of time to arsenic at doses equal to the worst-case dose estimated for this site; these symptoms are not likely to develop after a one-time exposure to arsenic as at this site.

The doses of antimony, copper and zinc were compared with the EPA's values for Acceptable Intake for Chronic Exposures (AIC) (USEPA, 1986c). Both the average and upper 95% concentrations of zinc are below the AIC established for this metal. The average concentration of copper is below the AIC (0.037 mg/kg/day), though the upper 95% concentration on site exceeds this value by about three-fold. The upper 95% concentration of antimony also exceeds the AIC for this metal by nearly two-fold, but it is an order of magnitude below the Lowest Observed Adverse Effect Level for animals based on a chronic feeding study in rats (USEPA, 1988a).

In summary, the concentrations of the metals detected in the surface water runoff are not believed to pose a significant acute hazard based on comparisons to acute and chronic exposure criteria. Chronic exposure is not possible due to the lack of permanent surface water sources on site (excluding Commencement Bay). The surface water pathway was thus generally considered to be a less significant route of exposure than the other pathways examined.

# 4. Inhalation

Exposure to chemicals in soil may result from inhalation of dust or from inhalation of volatile chemicals emitted from soil. The latter pathway was not quantified in this

assessment because aite-specific emission rates are unavailable and therefore no meaningful risk estimates could be derived. However, this is not considered to be a major limitation, because volatilization is not expected to contribute significantly to overall site risk, based on the low vapor pressures of the organic indicator chemicals (PCBs and PAHs; Table II-B) and empirical findings at similar sites (ETI, 1988). Of the two organic indicator chemicals, PCBs have the higher vapor pressure and have been shown by theoretical models to possibly be a significant source of exposure via volatilization (USEPA, 1986b). Nevertheless, PCBs are localized to a few samples on the property, and thus would not be expected to result in ambient concentrations in air at levels of concern.

A wealth of occupational literature has documented that volatilization is a significant exposure pathway for elemental mercury (USEPA, 1984f). However, this pathway is not likely to be significant at the site because (1) mercury concentrations at the site are low relative to concentrations in occupational studies; (2) other forms of mercury are likely to be present, such as inorganic mercury, which has low vapor pressure; and (3) mercury has low mobility in soil because of adsorption to organic matter and particulates (USEPA, 1984f; Goyer, 1986). In addition, total mercury was measured in surface dust samples taken at the site. Consequently, exposure to mercury via airborne dust is evaluated in the risk assessment as the primary means of exposure via inhalation.

Estimates of ambient air concentrations and deposition rates of metals were generated using mathematical models using on-site surface dust analyses performed by NEA, Inc. (Parametrix et al., 1989). The NEA analysis of 22 surface samples provided information on the relative concentrations of metals and on the particle size distribution in dust. For the limited data available, monitoring data were compared to modeling estimates to gain an indication of model performance (Parametrix et al., 1989).

Inhalation of organic chemicals adsorbed to dust particles was not quantified in this assessment because of the lack of site data on ambient levels of organics and the lesser significance of this route for these chemicals compared to the ingestion route. For example, inhalation risks for the organic chemicals of concern would be one to two orders of magnitude less than the oral risks even if one assumes the maximum federal allowable level of dust in air, 50 ug/m3 (PM<sub>10</sub>; CFR40 Part 50), and that concentrations in dust are equivalent to those in soil.

As discussed previously for ingestion, estimations of exposure via inhalation should be sensitive to the percentage of absorption if absorption is likely to differ for the population at risk from the population used to develop the toxicity criterion for a given chemical. Except for arsenic, absorption of metals by inhalation of fugitive dust was assumed to be 100%, or

identical to the percentage absorption assumed in the development of the toxicity criteria. For arsenic, the EPA Carcinogenic Assessment Group (CAG) corrected the potency slope to 100% absorption by assuming that arsenic absorption was 30% in the human population studied, as supported by the scientific literature (USEPA, 1984a). Consequently, in using the EPA arsenic criterion to assess risks for the populations at the site, a 30% absorption of inhaled arsenic was used to correct the potency slope back to the more accurate absorption rate in humans.

#### 5. Dermal Absorption

This route of exposure is not included in the 1986 guidelines for conducting a baseline risk assessment (USEPA, 1986c). Nevertheless, dermal absorption can be a significant route of exposure for many organic chemicals and can contribute to systemic levels of these chemicals (USEPA, 1986b; Hawley, 1985). We have included this route where justified, using conservative assumptions to account for the inherent difficulty in determining the relationship between dermal exposure and actual dose received and in extrapolating from ingestion or inhalation data to the percutaneous route. Whether the systemic effects of dermal absorption can be estimated by criteria derived for other routes depends on the scientific basis for the oral or inhalation criteria (see Toxicity Assessment, Section IV). Oral or inhalation criteria based on systemic effects are more applicable to the evaluation of a systemic dose via dermal absorption than criteria based on adverse effects at the site of entry (i.e., GI tract or lungs). Currently, EPA toxicity criteria are derived for only the oral and inhalation routes, so it is not possible to make a quantitative assessment of adverse effects on the skin as a target organ. Thus, the systemic effects of dermal absorption are the only scientifically justifiable evaluations of dermal exposure using current federal guidelines.

#### a. Inorganic Chemicals

Dermal absorption has been shown to be negligible for the metals of concern, with the possible exception of mercury (USEPA, 1984a; USEPA, 1986a; ACGIH, 1986). Some forms of mercury, particularly in pharmaceutical ointments, have been show to be absorbed to a limited extent through the skin; however, the available data are insufficient to quantify the amount that would be absorbed from soil. Moreover, there is a general agreement in the literature that this route of exposure is of much less significance than ingestion or inhalation (USEPA, 1984g; Goyer, 1986; Berlin, 1986; ATSDR, 1989). Dermal absorption of mercury from soil is also likely to be less than for direct application of mercury to skin, because mercury complexes and strongly binds to soil particulates, thereby greatly reducing its mobility (USEPA, 1984e). Therefore, due to the uncertainty in estimating

absorption for this route and the lesser significance of this route, dermal absorption of mercury was not assessed quantitatively. The uncertainty introduced by not quantifying dermal absorption of mercury is discussed in Appendix E.

At high concentrations, several metals also have the potential to cause dermal irritation. These effects are described qualitatively in Section IV, Toxicity Assessment and in Appendix D.

#### b. Organic Chemicals

Relatively few studies have measured dermal absorption in humans. Most of the data on humans are from occupational exposures frequently involving acute or subchronic effects such as corrosiveness or dermal irritation (ACGIH, 1986). Because guidelines are currently lacking to assess these effects quantitatively, these effects are described qualitatively in Section IV, Toxicity Assessment and in Appendix D.

Most quantitative dermal absorption studies have been performed on laboratory animals such as rabbits, rats, mice, and occasionally pigs and dogs. In one of the few studies using human subjects, a variety of organic compounds applied to the skin for one day resulted in 50% or less systemic absorption as measured by appearance in the urine (Feldmann and Maibach, 1970). Bartek et al. (1972) reported that human skin is 10 times less permeable to organic chemicals than rabbit skin and three to 10 times less permeable than rat skin. Absorption by children, on the other hand, may be twice that of adults (Hawley, 1985).

Dermal absorption of organic chemicals from soil depends on the chemical's molecular weight and K<sub>OC</sub> (which is indicative of the lipophilic nature of a compound and its propensity to adsorb to organic matter in soil). Generally, smaller molecules are able to penetrate the skin more readily than larger molecules (Feldmann and Maibach, 1970). The "soil matrix effect" is reported to decrease absorption of organic chemicals in two ways: (1) by decreasing the amount of direct contact between the compound and skin, and (2) by physico-chemical bonding to soil particles (Hawley, 1985; Abdel-Rahman and Turkall, 1989). Bonding to soil particles is directly related to the organic content of the soil and the lipophilic nature of the chemical. For example, dermal absorption of dioxin, a highly lipophilic compound, was almost completely prevented when it was applied to the skin of rats in combination with activated carbon. Dermal absorption of dioxin in soil by rats was reduced 85% compared to the absorption of a dioxin-methanol solution applied directly to skin (Poiger and Schlatter, 1980).



By comparison, the absorption rate of benzene, an organic solvent with a lower molecular weight, is reported to be reduced 30% when applied to the skin of mice in combination with soil versus as pure benzene (Abdel-Rahman and Turkall, 1989). These authors also report that pure benzene is poorly absorbed through the skin relative to oral administration.

Dermal absorption of benzo[a]pyrene is reported to be 40% in 24 hours when applied to mouse skin (Heidelberger and Weiss, 1951). Nevertheless, because HPAHs, like dioxin, are highly lipophilic compounds, the soil matrix effect (discussed above for dioxin) should reduce dermal absorption of HPAHs by approximately 85% (Hawley, 1985). Due to the uncertainties in this estimate of the soil matrix effect, we assumed conservatively that the rate of absorption of pure benzo[a]pyrene would be the same in mice as in humans, although experimental data indicate that human skin is a more effective barrier against dermal penetration by organic chemicals than the skin of many laboratory animals (Bartek et al. 1972).

If the assumed 40% dermal absorption rate is reduced by an estimated 85% due to the soil matrix effect, then the resulting dermal absorption rate is 15% of 40%, or 6%. A 6% absorption rate of benzolal pyrene assumed here is similar to the reported human dermal absorption rate of another highly lipophilic aromatic class of chemicals, PCBs (1%: USEPA, 1986b).

Unfortunately, dermal absorption of benzolalpyrene cannot be evaluated by the EPA toxicity criteria developed for other routes, because the ingestion and inhalation criteria are not based on systemic effects. Thus, health risk associated with the systemic dose by the dermal route of exposure cannot be calculated with the present guidelines. In addition, carcinogenic effects on skin as a target organ cannot be addressed because of the lack of an EPA criterion for assessing skin cancer risks. The effects of these data gaps on the results are discussed in the uncertainty section of this report (Section VI.)

Table III-B summarizes the percentage of absorption for the various routes of exposure.

#### 6. Exposure to Slag

The fused dross separated from copper ore during the smelting process is a glassified compound called "slag", which is rich in all of the elements found in the ore. Slag contains high levels of arsenic, copper, zinc, and lead, and lower levels of nickel, cadmium, and silver (Battelle Pacific Northwest Laboratories, 1986). Based on the average levels of metals in three surface slag samples at the Asarco site (Volume 2, RI report), arsenic (8,617 ppm), copper (7,950 ppm), lead (4,283 ppm), nickel (769 ppm), zinc (14,917 ppm) would be the

principal chemicals of concern at the site. These surface samples may also be contaminated by metals in fugitive dust.

Nevertheless, the assumption that the metals are 100% bioavailable from ingested slag is highly unlikely. The bioavailability of metals in slag is low because they are incorporated in an insoluble, vitreous iron and aluminum silicate matrix. Limited exposure to the metals is possible in two ways: 1) ingestion or inhalation of weathered slag particulates, followed by biochemical solubilization in the body: 2) leaching of the metals from the slag in situ, transfer into soil, ingestion and inhalation of soil.

Two recent studies of the bioavailability of arsenic in Tacoma smelter slag have been conducted. The first was a study of the pulmonary and gastrointestinal absorption of arsenic from particles of the slag in mice (Boyajian, 1987). This study determined that the arsenic in Tacoma Smelter slag (arsenic content: 3,000 ppm) is much less bioavailable than the arsenic in soil from Ruston, Washington, that contained 2,000 ppm arsenic. This study, however, was unable to measure quantitatively the relative decrease in bioavailability of arsenic in slag.

in a limited epidemiological study conducted by the Tacoma-Pierce County Health department, the arsenic body burden of small children exposed to pulverized slag for longer than six months was measured (Allen et al., 1988). The pulverized slag had been sold to local residents for use in landscaping. The arsenic body burden of children aged 2-7 years who were exposed to the slag at their homes was estimated by measuring urinary arsenic concentrations. The study was designed to test the hypothesis that children exposed to the slag via direct contact, inhalation, or ingestion had a higher body burden of arsenic than children not exposed to the slag. A comparison of the urinary arsenic concentrations revealed that there was no significant difference between the cohort and unexposed children.

Leaching of metals from the slag in seawater and freshwater has been studied by Crecelius (Battelle Pacific Northwest Laboratories, 1986). The results of the study indicate that copper is leaching at the highest rate, followed by arsenic, lead, and silver. The *in situ* leaching behavior of the slag was also studied as part of the Remedial Investigation at the site (Parametrix *et al.*, 1989). Leaching of these metals drops off rapidly after the slag is initially exposed to the environment. After three to four months in flowing seawater, the leaching rate of metals in slag and the associated toxicity decrease markedly. As a result, it was concluded that the Tacoma smelter slag is an insignificant source of metals to Puget Sound (Battelle Pacific Northwest Laboratories, 1986). These results suggest that metals in



weathered slag at the Asarco site is far less bioavailable following ingestion than the metals present in soil.

In summary, the available studies on the smelter slag indicate that exposure to metals in the slag at the Asarco site is likely to be minimal compared to the metals deposited in soil by stack and fugitive emissions. Arsenic is the metal present in highest concentration relative to its toxicity. Studies of slag from this site have shown that arsenic in the slag is less bioavailable than arsenic in lower concentrations in soil, and that children exposed to the slag do not appear to accumulate arsenic. Because exposure to arsenic in slag is not expected to be of potential health concern, exposure to other metals in the slag is assumed to be unlikely as well.

#### C. INTAKE RATES

#### 1. Soil Ingestion

The rate of soil ingestion is based on the amount of soil and dust a child eats in a given day. Several different rates of ingestion have been published in the scientific literature. Recently, soil ingestion rates have been determined by empirical data which can be used to derive more realistic soil ingestion rates for the purpose of risk assessment than previous guidelines that are based on mouthing behavior and amounts of soil on hands of children (La Goy, 1987). Typical estimates of soil and dust ingestion rates of children range from 0.05 to 0.1 grams per day (g/d) depending on age. Maximum or worst-case rates that are likely to overestimate actual exposure are 0.25 to 0.5 g/d. In addition, soil ingestion rates have also been estimated for adults who may ingest soil during gardening or caring for pets (0.025 g/d, typical; 0.1 g/d, worst-case).

Exposure to residents was thus calculated for a range of soil ingestion rates from typical to worst-case using rates reported by La Goy (1987). The breakdown of typical and worst-case ingestion rates for different age groups are displayed in Table III-E. These rates are comparable to ranges recommended by EPA guidance documents (USEPA, 1986c) and by the Endangerment Assessment (Black and Veatch, 1988).

Workers exposed to worst-case conditions are assumed to ingest more soil in the course of their day than the typical adult resident. We therefore used the ingestion rate of the six to 11- year-old age group (0.25 g/d) to approximate these workers (La Goy, 1987). Commercial industry workers in the "typical" industrial exposure scenario are unlikely to



# TABLE III-E INTAKE RATES FOR DIFFERENT AGE GROUPS

AGE (years)	· ·		TIONa	INHALATION RATE (m <sup>3</sup> /day)	DERMAL CONTACT (g/day)		
· 		Typical	Worst-case	Leafy	Root		
Publicb				•			
0-1	4.9	0.05	0.25	0.50	0.53	5.0	0.0
1-6	15.5	0.10	0.50	0.29	0.44	7.5	10.0
B-11	33.1	0.05	0.25	0.51	0.77	12.0	1.0
11-76.2	70.0	0.025	0.1	1.44	1.04	20.0	0.1
Workersc							
20-60 (light)	70.0	0.025	••			8.25	0,10
20-60 (heavy)	70.0		0.25	-	-	25.75	0.65

a Values are "worst-case" (for rural populations); "typical" intake is half of these values (USDA, 1966; USFDA, 1981; Pennington, 1983).

b Assumptions from La Goy (1987), USEPA (1986c), Black and Veatch (1988). Body weight is an average weight for the age group.

<sup>&</sup>lt;sup>c</sup> Assumptions from Hawley (1985), Hallenbeck and Cunningham (1986), La Goy (1987), USEPA (1986c).



come in contact with soil; however, we conservatively assumed that they ingest soil at the "typical" rate of adult residents (0.025 g/d).

# 2. Home-Grown Vegetable Ingestion

Ingestion rates of vegetables are U.S. population averages for consumption of leafy and root vegetables (USFDA, 1981; Pennington, 1983). For each type of produce, the consumption rates were multiplied by the fraction of each type of produce that was home-grown in rural areas (USDA, 1966). Because these calculations are likely to overestimate the amount of home-grown leafy and root vegetables eaten in non-rural Ruston, the "typical" ingestion rate of home-grown vegetable consumption assumed for this assessment is half of that calculated for rural areas. Table III-E displays the resulting home-grown produce intake rates (dry weight basis) used to calculate exposure by this pathway.

#### 3. Dust Inhalation

The inhalation rate of adults (ages 11 to 76.2) was assumed to be 20  $m^3$ /day as recommended by USEPA (1986c). USEPA (1986c) also recommends an inhalation rate of 5  $m^3$ /day for children. USEPA's rate was assumed for infants, and inhalation rates for intermediate age groups in the assessment were derived by linear interpolation between 20 and 5  $m^3$ /day.

Inhalation rates for "worst-case" and "typical" industrial exposure were 25.75 m<sup>3</sup>/day and 8.25 m<sup>3</sup>/day, respectively, for a 10-hour work day (Hallenbeck and Cunningham, 1986). Heavy industry workers are assumed to be performing more strenuous activities during the course of the work day, whereas light industry or office workers are more sedentary. The inhalation rate of the latter workers was calculated by assuming that these workers engage in "light activity" for half the work day and are at rest for half the work day (Hallenbeck and Cunningham, 1986).

# 4. Dermal Contact

Dermal contact rates for residents have been defined by the Centers for Disease Control for various age groups (Table III-E; Kimbrough et al., 1984). For worst-case industrial exposure which is likely to result in a higher dermal contact rate, we used the dermal contact rate measured for workers in a fertilizer mixing plant (0.65 g/day over a 10-hour work day; Hawley, 1985). The "typical" dermal contact rate assumed for commercial workers was the contact rate given for adult residents (Kimbrough et al., 1984).



#### D. EXPOSURE CONCENTRATIONS

#### 1. Soil

### a. Degradation of Chemicals

The organic chemicals of concern have the potential to break down over time in the soil. If breakdown is significant during the period of exposure, the effective soil concentration of a chemical will be less than the initial concentration measured. Some organic chemicals break down in sunlight by a process called photolysis. This process, however, may be restricted to the thin layer of surface soil. Since contaminants are present below the thin surface layer, it was conservatively assumed that photolysis would not decrease levels of exposure at the site.

A more significant mechanism of removal for some organic chemicals in soil is microbial degradation. Of the site chemicals, PAHs had the shortest half-life by this mechanism. The half-life of PAHs in soils is reported to be one day to a few years, whereas in sediments, the half-life is longer, on the order of five to ten years (USEPA, 1984f). PAHs in oily sludges are reported to be more completely degraded in soil (85%) than are total hydrocarbons (Bossert et al., 1984). Petroleum products which contain HPAHs are also reported to be toxic to soil microbes, although reduction in biodegradation rate occurs at highly concentrated petroleum levels in soil (30 to 50% petroleum by volume; Eastcott et al., 1989).

This assessment of HPAH degradation assumed a half-life in soil of five years and that degradation follows a first-order kinetic model. Degradation was conservatively assumed to begin when the populations at risk are exposed to the site. In reality, several years may pass between the measurements of concentrations in soil and the occupation of the site by future populations. Concentrations of all other chemicals were assumed to remain constant over time. Exposure calculations for HPAHs are presented in Appendix B.

#### b. Calculation of Exposure Concentrations

Exposure concentrations of chemicals in surface soils were calculated from the sampling data provided by Parametrix, Inc. (see Volume 2 of the RI report). The summary statistics developed for each indicator chemical at each site were a mean and an upper 95th percentile (population) level for "typical" and "worst-case" exposure, respectively.

Table III-F presents the exposure concentrations of the indicator chemicals.

TABLE III-F

# CURRENT SITE SOIL CONCENTRATIONS OF INDICATOR CHEMICALS FOR INGESTION AND DERMAL ROUTES OF EXPOSURE (PPM)

CHEMICAL	MEAN	UPPER 95% LEVI	EL
Metals	·		
Antimony	139.	953.	•
Arsenic	9,776.	70,389.	
Cadmium	67.	256.	
Copper	11,688.	84,494.	12 - 12 - 1
Lead	3,809.	13,476.	
Mercury	<b>79.</b>	351.	·
			<u>.</u>
Organics			
Dibenzofurana	0.54	2.58	19.
Dibenzothiophenea	0.41	1.60	
HPAHs	41.60	285.58	٠.
m-Nitroanilinea	1.24	1.41	
PCBs	0.89	2.63	

<sup>&</sup>lt;sup>a</sup> Available data are insufficient to evaluate risks quantitatively



# 2. Concentration of Metals in Vegetables

Concentrations of metals in garden vegetables were calculated by multiplying the uptake rate of a metal by leafy or root crops (Table III-C) by the soil concentration of the metal (Table III-F). Only soil concentrations that were below the level for phytotoxicity were considered to produce viable crops and thus result in exposure to metals by this pathway.

#### 3. Concentration of Metals in Airborne Dust

Ambient levels of metals in fugitive dust for onsite and offsite receptors were calculated using the ISCLT and FDM models by TRC Environmental Consultants. The FDM model was preferred because it more accurately calculates particle deposition and is more conservative in estimating deposition and ambient concentrations.

Arsenic was assumed to be in the form of arsenic trioxide, a major product from copper smelting. TRC estimated the concentration of the metals relative to the concentration of arsenic as determined from the surface soils analysis of NEA, Inc. (Parametrix et al. 1989) Exposure was calculated using annual average concentrations because chronic exposure is more relevant for evaluating long-term risks of chemicals at this site. These exposure concentrations of metals in air are presented in Appendix C.

For onsite populations, "worst-case" exposure assumes an individual is exposed at the location of the highest maximal annual average (generally in the stabilization area of the copper and arsenic processing buildings). By contrast, typical exposure assumes an individual is exposed at the location of intermediate ambient levels on site. Figure 5 (in Appendix C) depicts the selection of this isopleth from the data provided in Volume 1 of the RI report.

The location of maximum exposure to offsite populations was determined to be along the northwestern boundary of the site (see Appendix C, Figure 5). The "typical" impact for the nearby offsite population was determined to occur approximately 0.4 kilometers west of the location of the maximum offsite ambient concentration at the site boundary, as depicted in Figure 5.

### 4. Offsite Deposition of Fugitive Dust

The increase in soil concentration due to offsite deposition of arsenic was calculated to assess the increase in arsenic exposure caused by fugitive dust from the site. TRC



Environmental Consultants modeled annual deposition rates of arsenic trioxide using FDM and ISCLT models. Again, FDM gave the most conservative results which were therefore used in this report. Quantities of other metals deposited were assumed to be in the same proportions relative to arsenic that occur in surface dust samples at the site (Parametrix et al., 1989). The highest offsite deposition rates on residential property are at the northwest border of the property (Figure 6 in Appendix C). Here, total annual deposition is estimated to be  $0.035 \, g/m^2/year$  (see Table C-2 in Appendix C for deposition rates of other metals). By contrast, arsenic deposition at the "typical" receptor location in Ruston is  $0.0028 \, g/m^2/year$ , about ten times less.

The increase in soil concentration caused by this deposition rate was calculated assuming the bulk soil density reported for Ruston (0.75 g/cm<sup>3</sup> average in the top 10 cm; USDA Soil Conservation Service, 1988), a mixing depth of one cm, and no loss or dilution by other sources of deposition over time. The maximum annual increase in arsenic concentration in the soil is 4.67 ppm which would result in a 356 ppm increase over a lifetime (76.2 years), assuming no loss or dilution of arsenic. This maximum annual increase represents a 0.3% increase in the present upper 95 percentile (geometric mean plus two standard deviations) of soil arsenic levels within a half mile of the smelter (1,361 ppm, average of playgrounds and empty lots ["high use"] and residential property; Black and Veatch, 1988).

#### E. POPULATIONS AT RISK AND DURATION OF EXPOSURE

All exposure scenarios in this study assume that no contamination will be removed from the site (the "no-action alternative"). To adjust for the amount of time that people would be exposed to chemicals in soil, exposure was multiplied by a correction factor for different site uses and for children and adults (Table III-G).

At this time, the property is fenced and isolated from the public. Access is restricted to workers who gain access from a security guard stationed at the locked site entrance. Each population considered in the exposure scenarios for this study is described below.

#### 1. Onsite Residents

A hypothetical population that would be at greatest risk from exposure to the chemicals of concern at the site would be made up of individuals who were year-round residents of the site. The residential scenario was designed to estimate this worst-case exposure. If year-round residents are not at risk, then it follows that visitors to the site will not be at risk either.



TABLE III-G
CORRECTION FACTORS FOR DURATION OF EXPOSURE

EXPOSURE ROUTE	F	ONSITE RESIDENTIAL		ONSITE INDUSTRIAL	OFFSITE RESIDENTIAL	
•		Worst-		Worst-Case	Worst-	<b>.</b>
	·	Case	Typical	& Typical	Case	Typical
Inhalation	adult*	1	<b>0.7</b>	0.71	1.0	0.7
	child	1	1	0	1.0	1.0
Soil Ingestion	adult	0.5	0.5	0.36	0	0
	child	0.5	0.5	0	0	0
Vegetable Ingestion	adult	1	0	0	0	
	child	1	1	0	0	0
Dermal	adult	0.5	0.5	0.36	0	0
	child	0.5	0.5	0	0	0

<sup>\*</sup>Ages 6 to adult

Note: see text for rationale used to develop assumptions.



All routes of exposure are considered applicable to adult and child residents for a 76.2-year lifetime at the site. A 76.2-year lifespan was used for consistency with the 1988 Endangerment Assessment, which estimated arsenic exposure experienced by offsite residents (Black and Veatch, 1988).

Children are considered the most sensitive subpopulation of those potentially exposed at the site for non-carcinogenic health effects. Children six years old or younger generally have greater exposures to soil because of normal hand-to-mouth activity or in extreme cases because of pica (ingestion of non-food items, e.g., soil). In addition, children are inherently more susceptible to toxic effects of heavy metals or organic chemicals for a variety of reasons: (1) much more efficient absorption of many substances from the gastrointestinal tract than adults, (2) increased prevalence of dietary deficiencies such as calcium, an essential element that decreases lead and cadmium absorption, (3) higher metabolic rate relative to body mass, thereby affecting dose per body weight, and (4) lower thresholds for adverse effects of non-carcinogenic chemicals.

For carcinogenic effects, which depend on cumulative exposure, residents who live their entire lives at the site are considered to be the individuals of greatest health concern.

"Worst-case" and "typical" exposure via ingestion of soil and dermal contact was assumed to occur for approximately six months of the year (i.e., during warm, dry weather) because children and adults are unlikely to contact soil when it is cold and wet (USEPA, 1986b). Although dust formation is less likely when the soil is wet, a seasonal factor of 0.5 was not used for dust inhalation exposure because the levels of dust assumed at the site are annual averages that incorporate seasonal variation (Parametrix et al., 1989). Daily intake of home-grown vegetables is likewise assumed to be an average over the whole year and did not require seasonal correction.

For inhalation exposure, calculations of "worst-case" exposure for this population assumed that the maximally exposed individual resides on the site 100% of the time, whereas a "typically" exposed individual leaves the site area to work or attend school ten hours a day, five days per week between the ages of and 76.2, which is equivalent to spending 70% of the time in the area, and is therefore still a conservative assumption. (The nearby Ruston school has been closed).



#### 2. Industrial Workers

In the second scenario, the site is assumed to be a future location for either light or heavy industry. Adult workers are the main population of concern. No children are present. The most exposed population is assumed to be heavy industrial workers who work outside and regularly contact soil (worst-case exposure). As a comparison, exposure is also evaluated for a light industrial worker who spends more time indoors (typical exposure).

Exposure for workers is conservatively based on a five-day work week. Five out of seven days is 71% of the days as opposed to the daily exposure (100%) assumed under the residential scenario (Table III-G). All routes of exposure are considered for the industrial scenario except for consumption of home-grown vegetables. Ingestion of soil and dermal contact are also assumed to occur mainly for an average of six months of the year during warmer, drier weather. The daily intake rates assumed for workers are based on a total in a ten-hour work day (see below), and therefore no additional correction for the percentage of the day on site is needed.

# 3. Offsite Residents

Risks due to exposure to arsenic in offsite soils and in air have been evaluated previously by the Endangerment Assessment (Black and Veatch, 1988). This assessment used ambient monitoring data on arsenic in airborne dust which primarily represent the impacts during plant operations and, more recently, plant demolition. The present assessment uses ambient levels in air and deposition rates modeled by TRC to better estimate the extent of risks due to current exposure to metals in fugitive dust originating from the site. The quantitative effect of the input of arsenic to offsite soil due deposition is then compared to the risks calculated by the Endangerment Assessment for this population. Incremental risks due to current and hypothetical future deposition of arsenic are calculated for soil ingestion exposure by offsite residents, assuming the above soil intake assumptions.

The route of exposure that was calculated directly for this population is the inhalation of metals in fugitive dust, as discussed above. Calculations of duration of exposure are similar to those used for onsite residents (above). The "worst-case" condition for this population assumed that the maximally exposed individual resides in the area 100% of the time, and that a typically exposed individual leaves the area to work or attend school ten hours a day, five days per week between the ages of 6 and 76.2.



#### F. CALCULATION OF DOSE

For each route of exposure and age group, a dose was calculated for indicator chemicals by the equation:

Dose =  $EC \times IR \times CF \times AB / BW$ 

where:

EC = exposure concentration (Tables III-C, III-E)

IR = intake rate (Table III-E)

CF = correction factor for exposure duration (Table III-G)

AB = percent absorption (Table III-B)

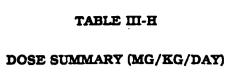
BW = body weight (Table III-E).

The dose by each route of exposure, (inhalation, ingestion (soil and vegetables), and dermal (Table III-H)), is then compared to the relevant EPA toxicity criteria for the specific route and chemical. The highest dose of any age group in mg/kg/day is used to evaluate non-carcinogenic chemicals (zero to one year olds). For carcinogens, an average lifetime dose is calculated by (1) weighing the dose of each age group (e.g., six to 11 year olds) by the length of time spent in that age group (e.g., five years), (2) summing the time-weighted doses from all age groups, and (3) dividing by lifespan (76.2 years). Spread sheet examples of these calculations are presented Appendix B for arsenic, lead, and HPAHs.

The next section (IV.) describes the toxicity criteria which are based on the toxicological effects of the chemicals. The risk characterization section (V.) discusses how the non-carcinogenic and carcinogenic health risks are calculated using the dose and toxicity information.

#### G. SUMMARY

This risk assessment considers onsite exposure to hypothetical residents, onsite exposure to workers, and offsite exposure to residents. Exposure pathways of concern for onsite residents include soil ingestion, home-grown vegetable ingestion, inhalation of metals in dust, and dermal exposure to organic chemicals in soil. Industrial workers are assumed to have similar exposure pathways of concern, with the exception of consumption of home-grown vegetables. Exposure to offsite residents is mainly examined for inhalation of metals





		HYPOTHETICAL ONSITE			•	T OFFSITE
CHEMICAL by	RESIDENTIAL INDUSTRIAL			RESIDENTIAL		
Pathway 	Worst-Case	Typical	Worst-Case	Typical	Worst-Case	Typical
Inhalation						
Arsenic*	2.5E-05	9.6E-06	1.1E-05	1.8E-06	7.4E-06	7.6E-0
Cadmium*	6.9E-07	2.7E-07	3.1E-07	5.1E-08	2.1E-07	2.1E-0
Chromium*	1.4E-06	5.5E-07	6.3E-07	1.1E-07	4.2E-07	4.3E-08
Copper	9.8E-05	5.1E-05	7.3E-05	1.2E-05	2.9E-05	4.0E-06
Lead	1.2E-04	4.3E-05	6.2E-05	1.0E-05	3.6E-05	4.9E-06
Mercury	7.2E-05	2.6E-05	3.8E-05	6.3E-06	2.2E-05	4.9E-06
Nickel <sup>®</sup>	2.1E-06	7.6E-07	9.2E-07	1.5E-07	6.2E-07	6.3E-08
Soil Ingestion						
Antimony	1.2E-02	3.5E-04	1.2E-03	1.8E-05	-	
Arsenic*	6.0E-02	1.8E-03	1.9E-02	2.6E-04		
Cadmium	3.2E-03	1.7E-04	3.3E-04	8.6E-06		
Copper	1.1E+00	2.9E-02	1.1E-01	1.5E-03		
Lead	7.1E-02	4.0E-03	7.3E-03	2.1E-04		••
Mercury	1.8E-03	8.3E-05	1.9E-04	4.3E-06	-	
HPAHs*	1.3E-04	3.9E-06	1.1E-06	1.6E-08	••	
PCBs*	1.7E-06	1.5E-07	1.1E-06	3.3E-08	-	-
Vegetable ingest	ion					
Arsenic*	4.5E-03	3.1E-04	-	_		-
Cadmium	1.6E-02	2.1E-03				-
Copper	5.5E-01	3.8E-02	-		-	
Lead	7.2E-03	1.0E-03			~	
Mercury	4.5E-03	5.1E-04	<del>-</del>	-		-
Dermal Contact			•			
HPAHs*	2.4E-04	3.5E-05	3.3E-07	7.5E-09	~	
PCBs*	6.2E-07	1.9E-07	9.1E-08	4.4E-09	_	

Note:

 $2.5E-05 = 2.5 \times 10^{-5}$ 

<sup>\*</sup>Dose for carinogens is the average lifetime dose

<sup>-</sup>Not a relevant pathway; see text



in fugitive dust from the site. The impact of deposition of dust on the increase in risks due to subsequent soil ingestion (Black and Veatch, 1988) is also evaluated.

In the quantitative risk assessment, the chemicals of concern for the soil ingestion pathway are antimony, arsenic, cadmium, copper, lead, HPAHs, and PCBs. Arsenic, cadmium, copper, and lead are the chemicals of concern for the vegetable ingestion pathway. The organic chemicals are most important for dermal contact exposure. Arsenic, cadmium, chromium, copper, lead, and nickel are the chemicals of concern for inhalation exposure.



# IV. TOXICITY ASSESSMENT

This section summarizes the relevant toxicity criteria which are used in this report to assess the risks associated with the dose of the indicator chemicals to which onsite and offsite populations are assumed to be exposed, as determined in the previous section. Appendix D. provides more detail on the toxicological effects of the indicator chemicals of greatest concern.

#### A. TOXICITY CRITERIA

The EPA toxicity criteria used in this risk assessment were obtained from the most current source, an on-line database called the Integrated Risk Information System (IRIS) maintained by USEPA. To characterize a chemical not listed with IRIS, we contacted EPA directly to obtain further guidance. Some chemicals may have approved criteria that have not yet been entered into IRIS. For chemicals that lack EPA criteria, such as dibenzofuran and m-nitroaniline, the existing toxicological data on the chemicals were reviewed and the likelihood of adverse effects predicted to the extent permitted by the data.

Although exposure to some of the indicator chemicals at the Asarco site may result in both non-carcinogenic and carcinogenic effects, to date the EPA has published chronic toxicity criteria for either non-carcinogenic or carcinogenic effects for each Asarco indicator chemical, but not both. Because carcinogenic effect are usually of most concern for chronic exposure (are more likely to occur at the lowest doses), non-carcinogenic effects that occur at higher levels are considered of less importance and often do not have EPA guidelines. Supplementary information on the toxicity of these chemicals is presented in Appendix D.

# 1. Criteria for Non-Carcinogenic Effects

The acceptable intake for chronic exposure (AIC) is the highest human intake of a chemical, expressed as mg/kg/day, that does not cause adverse effects when exposure is long-term (lifetime). AIC values are based on long-term animal or human chronic toxicity studies. When EPA completes verification of the chronic toxicity of a specific chemical, it establishes a "reference dose", or RID. If the RID for a chemical has been established, then the RID is used as the AIC for evaluating long-term non-carcinogenic risks at the site. This "acceptable" dose is compared to the dose calculated from the exposure assessment to determine whether adverse effects might occur. If predicted exposure concentrations are below the level of the regulatory AIC criteria, no adverse health effects are expected. The AICs for the chemicals of concern are listed in Table IV-A.





# TOXICITY CRITERIA FOR NON-CARCINOGENIC EFFECTS

CHEMICAL	AIC or RfD (mg/kg/day)		
	Oral	Inhalation	
		*****	
Antimony	4.0E-04	a.b	
Cadmium	2.9E-04	a	
Chromium VI	5.0E-03b	a	
Copper	3.7E-02	1.0E-02	
Lead	1.4E-03	4.3E-04	
Mercury	3.0E-04	5.1E-05	

(USEPA, 1986c, 1988a, 1989a; see also Section IV. Toxicity Assessment)

a No EPA criterion established for this route

b Route is not of concern for this assesment (see Section III. B.)



# 2. Criteria for Carcinogenic Effects

For chemicals with carcinogenic effects, EPA calculates the cancer risk associated with a given dose by multiplying the dose from a given route of exposure by a cancer potency factor or potency slope. The EPA derives potency factors from the upper 95% confidence limit of the slope of the extrapolated dose-response curve, which shows the relationship between a given dose and the associated tumor incidence. As a result, the predicted cancer risk is an upper-bound estimate of the potential risk associated with exposure. This intentionally overestimates the actual risk in order to ensure protection of public health beyond a reasonable doubt. Table IV-B summarizes the potency factors for indicator chemicals with carcinogenic effects.

# 3. Criteria for Ambient Levels

While the EPA criteria described above are used to assess the health risks associated with elevated concentrations of hazardous substances, other agencies have set ambient exposure standards for permissible levels of hazardous substances in air. These standards were compared to the concentrations of the metals of concern detected in fugitive dust at the Asarco site.

### a. PEL/TLV

The Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental and Industrial Hygienists (ACGIH) have set exposure standards under which it is believed that nearly all workers may be exposed repeatedly without adverse effect. These standards are the Permissible Exposure Limits (PELs) and Threshold Limit Values (TLVs) which are time-weighted averages based on occupational exposure for an eight-hour day and a forty-hour week (ACGIH, 1987; OSHA, 1989). For the chemicals of concern at the site, PELs and TLVs are similar except as noted below.

Because workers are thought to be a generally healthier subset of the general population, occupational standards are not considered protective enough for more sensitive members of the general population even with a correction for differences in exposure period. These standards are used to evaluate risks for workers, assuming site use as an industrial or commercial facility.



# TABLE IV-B TOXICITY CRITERIA FOR CARCINOGENIC EFFECTS

CHEMICAL		POTENCY FACTOR (mg/kg/day)-1		
	Oral	Inhalation	Dermal	
Metals				
Arsenic	1.65E+00	5.00E+01	a,b	
Cadmium	a	6.10E+00	a.b	
Chromium VI	a	4.10E+01	a.b	
Nickel	a	1.70E+00	a.b	
Organics				
HPAHs	1.15E+01	6.11E+00b	a	
PCBs	4.34E+00	4.34E+00b	4.34E+00	

(USEPA, 1986c; 1988a; 1988e; see also Section IV. Toxicity Assessment)

a No EPA criterion available for this route

b Route is not of concern for this assesment (see Section III. B.)



# b. AAL

The Washington State Department of Ecology (WDOE) is currently in the process of developing Acceptable Ambient Levels (AALs) for the general population (WDOE, 1988). An AAL is an estimated concentration limit to which daily exposure by the general public is likely to be without appreciable risk of deleterious effects during a lifetime. These guidelines are not currently being enforced by WDOE, but have been adopted by the Puget Sound Air Pollution Control Agency (PSAPCA). Several sources were used to develop the AALs, including the AALs of the State of Massachusetts, TLVs (modified to account to more sensitive members of the general public), and the available toxicity data. The AAL guidelines were used both to screen for indicator chemicals and as an additional criterion with which to evaluate risk (Tables II-C and II-D). In general, however, the EPA risk assessment procedures are preferable to using the AALs because the risk assessment methodology is based on site-specific conditions and thus should be more accurate. In addition, data on the derivation of AALs are not as readily available and therefore AALs cannot be easily reviewed for scientific validity.

#### B. CHEMICALS OF CONCERN

#### 1. Antimony

Antimony at the site is assumed to be present as either metallic dust or as a mixture of soluble salts. The oral reference dose of  $4x10^{-4}$  mg/kg/day is based on a study of chronic oral administration of potassium antimony tartrate to rats in drinking water (USEPA, 1988a). The critical effects in this study were decreased longevity and altered blood glucose and cholesterol levels. No inhalation reference dose for antimony has been developed by EPA. However, the PEL for workers is 0.5 mg/m³ (ACGIH, 1987; OSHA, 1989), and the AAL set by the State is 1.2 ug/m³ (WDOE, 1988). Because the eight-hour maximum concentration at the site is three orders of magnitude below the PEL (Table IV-C) and two orders of magnitude below the WDOE AAL, antimony inhalation exposure was not considered in this risk assessment (Table II-D).

# 2. Arsenic

The toxic potency of arsenic varies with its chemical form. The primary forms of concern in this risk assessment are trivalent and pentavalent inorganic arsenic. Trivalent (arsenite) compounds are more toxic than pentavalent (arsenate) compounds, but in the environment arsenite is rapidly converted to arsenate (Goyer, 1986).



# TABLE IV-C

# ONSITE EIGHT-HOUR MAXIMUM CONCENTRATION COMPARED TO OCCUPATIONAL LIMITS (OSHA PEL)

HEMICAL	PEL <sup>a</sup> (ug/m³)	ONSITE 8 HR. MAX <sup>b</sup> (ug/m³)	8 HR MAX/PEL
ntimony	500.	0.72	0.0014
senic	10.	4.60	0.46
dmium	200.	0.04	0.0002
romium	50.	0.08	0.0016
pper	1,000.	4.81	0.0048
ad	50.	4.08	0.082
ercury vapor	50.	2.47	0.049
ckel	1,000.	0.12	0.0001

<sup>•</sup> OSHA (1989)

b Parametrix et al. (1989)



Risk assessments for arsenic are generally based on the induction of lung cancer by inhaled arsenic and the induction of skin cancers by ingested arsenic. These are the effects of greatest concern for chronic exposure to the low levels present at the smelter site.

Non-carcinogenic effects associated with chronic exposure include skin lesions, injury to peripheral and central nervous systems and a cardiovascular disorder known as blackfoot disease (USEPA, 1984a). These effects are described in detail in Appendix D of this report.

The inhalation potency factor of 50 (mg/kg/day)-1 was developed from studies of human males occupationally exposed to arsenic via inhalation (USEPA, 1988a). The AAL for arsenic (0.00023 ug/m³) is based on this potency factor, assuming lifetime exposure with a 20 m³/day inhalation rate and 70 kg body weight. The maximum annual average of arsenic in airborne dust on site exceeded this AAL by 1,000 times. By comparison, for workers, the PEL at 10 ug/m³ is two orders of magnitude higher than the eight-hour maximum on site (Table IV-C). The ACGIH TLV is 200 ug/m³.

The ingestion potency factor has recently been revised by CAG (USEPA, 1987b). The new estimate, 1.65 (mg/kg/day)-1, is almost an order of magnitude lower than the estimate issued in 1984, at 15 (mg/kg/day)-1. The difference is due to a revised evaluation of the same study upon which the original cancer potency factor was based. In this study, the incidence of skin cancer in people exposed to arsenic in drinking water in Taiwan was reanalyzed using the generalized multistage model and incorporating assumptions that are more realistic for the U.S. population. The differences between the two evaluations are summarized in detail in Appendix D.

# 3. Cadmium

The intake route of cadmium largely determines the nature of its toxic effects. The inhalation potency factor of 6.1 (mg/kg/day)-1 is based on the increased incidence of lung cancer in workers occupationally exposed to cadmium by inhalation. Cadmium is not currently believed to be carcinogenic via ingestion (USEPA, 1988a).

The oral non-carcinogenic AIC of 2.9 x 10<sup>-4</sup> mg/kg/day is derived from the EPA water quality criterion, which is based on the no effect level for proteinuria (kidney damage) in a human population exposed to cadmium-contaminated food (USEPA, 1984c). EPA has not developed an inhalation AIC for the non-carcinogenic effects of cadmium, and because the toxic effects of cadmium are route-specific, the oral AIC cannot be used to estimate non-carcinogenic inhalation effects. Therefore, the non-carcinogenic risks from inhalation exposure to cadmium were not quantitatively estimated in this assessment.



The symptoms of chronic cadmium toxicity are discussed in Appendix D. The AAL for cadmium is  $0.00056 \text{ ug/m}^3$ , whereas the PEL is  $200 \text{ ug/m}^3$  and the TLV  $50 \text{ ug/m}^3$ . Cadmium levels in air on site exceeded the AAL by 4 times, but the eight-hour maximum was several orders of magnitude below the allowable occupational exposure limits.

## 4. Chromium

Although the state of chromium at the site was not determined, both hexavalent (VI) and trivalent (III) chromium are possible at the site. Because no data were provided on the proportions of each valence present, the risk from chromium exposure was assessed using EPA criteria established for the more toxic hexavalent state. This is a conservative assumption which will likely overestimate risk.

Conclusive epidemiological evidence has established that chronic inhalation exposure to hexavalent chromium causes bronchiogenic tumors. In contrast, there are no human or animal studies indicating that chromium VI is carcinogenic via ingestion (USEPA, 1988a). The inhalation potency factor of 41 (mg/kg/day)-1 developed by EPA is based on data from an epidemiological study of occupational exposure to total chromium. In that study, it was assumed that one-seventh of the total chromium was in hexavalent (carcinogenic) form. Thus, the EPA has stated there may be as much as a seven-fold underestimation of the potential risk from pure hexavalent chromium exposure inherent in the EPA inhalation potency factor (USEPA, 1988a).

Although chromium exposure can cause a variety of non-carcinogenic toxic effects, these effects have not been observed following exposure to chromium concentrations as low as those at the site. The PEL for total chromium is  $50 \text{ ug/m}^3$ , which is a thousand times greater than the eight-hour maximum detected on site. An AAL has not been developed for hexavalent chromium.

### 5. Copper

High doses of copper are acutely toxic to humans; however, low doses are nutritionally essential. In individuals with normal copper metabolism and normal glucose-6-phosphodehydrogenase (G6PD) levels, there is a wide separation between required and toxic levels of copper intake (USEPA, 1984d). Chronic copper toxicity has not been documented in the general population (Aaseth and Norseth, 1986).



Reports of systemic effects of chronic exposure to copper are uncommon in the literature.

One reason may be because of the homeostatic regulation of copper absorption by the gastrointestinal tract and because ingestion of small amounts of copper causes vomiting (Goyer, 1986).

At some locations at the site, copper concentrations have been measured at 300,000 ppm. Contact dermatitis may result in sensitive individuals who are exposed to copper sulfate at this concentration. Acute effects reportedly associated with occupational exposure to copper dust and fumes are not expected at the site as the concentrations of copper dust and fumes are well below regulatory levels of concern (see below).

Because an RfD is not currently available for copper, the quantitative non-carcinogenic risk estimates of exposure to copper at the site were developed using the AlCs recommended in the EPA Superfund Public Health Evaluation Manual (USEPA, 1986c). The oral AlC of  $3.7 \times 10^{-2}$  mg/kg/day was derived from the LOAEL (lowest observed adverse effect level) for gastrointestinal effects in humans. The inhalation AlC of  $1.0 \times 10^{-2}$  mg/kg/day is based on the TLV for inhalation of copper mists or dusts (USEPA, 1984d; USEPA, 1986c).

Copper is not considered a carcinogenic metal by any exposure route (USEPA, 1988a). No human or animal carcinogenicity has been established. Equivocal data has been reported on its mutagenicity.

Copper has the highest AAL and PEL of the metals of concern. These levels are 2.4 ug/m<sup>3</sup> and 1000 ug/m<sup>3</sup>, respectively. Copper concentrations onsite are an order of magnitude below the AAL and three orders of magnitude below the PEL (Tables II-D and IV-C).

# 6. Lead

The existing criteria for the non-carcinogenic effects of lead are 1.4x10-3 mg/kg/day for oral exposure and 4.3x10-4 mg/kg/day for inhalation exposure (USEPA, 1986c). Exposure via these routes of exposure below these rates is not expected to result in adverse health effects in humans. However, these criteria are currently under review by the Agency in light of recent findings on the subtle effects of lead at low blood levels (see Appendix D).

Lead is classified as a probable human carcinogen (USEPA, 1988b). At present, the EPA recommends that "quantitative estimates of the carcinogenic potency of lead not be used for the purpose of risk assessment, because of the considerable uncertainty in the estimates" (USEPA, 1988b). Moreover, because lead causes tumors in laboratory animals only at very high doses, non-carcinogenic effects are of greater concern at low levels of exposure such as



those at the Asarco site (USEPA, 1988b). Therefore, only non-carcinogenic criteria were used to assess site risks.

Although there is no EPA verified reference dose (RfD) for lead, there is an AIC listed in the USEPA Superfund Public Health Evaluation Manual (USEPA, 1986c). The AIC used in this report is so conservative that average background soil concentrations of lead could yield a dose approaching the AIC. However, studies of blood lead levels in children indicate increases in blood lead levels are not significant until soil lead levels exceed 500 to 1,000 ppm (CDC, 1985).

The maximum annual average of lead in air on site is half of the AAL which is  $0.49 \text{ ug/m}^3$ . The eight-hour maximum level on site is two orders of magnitude below the PEL of 50 ug/m<sup>3</sup>. The TLV is 150 ug/m<sup>3</sup>.

# 7. Mercury

The majority of mercury present in site soils was probably deposited as inorganic mercury from smelter flue dust, although some unknown amount may be present as elemental mercury or as organomercurials formed by microbial action in the soil. The wide variation in toxicity among the forms of mercury possible at the site complicates predictions of potential risks from mercury exposure, as discussed in the uncertainty section of the report (Appendix E). As a result, this report uses the EPA toxicity criteria for the most toxic form of mercury possible by each route of exposure.

The verified reference dose (RfD) for oral exposure is the same for organic and inorganic mercury. This RFD  $(3x10^{-4} \text{ mg/kg/day})$  was calculated for the EPA drinking water criteria (0.01 mg/L) and is based on autoimmune effects (USEPA, 1989a).

For inhalation, the AIC for inorganic mercury salts,  $5x10^{-5}$  mg/kg/day, is based on the TLV for mercury vapor. This criteria is thus conservative because mercury vapor is very efficiently absorbed compared to the mercuric salts assumed to be present in inhaled particulates at the site. The AIC for alkyl mercury and other organic mercury compounds is based on chronic occupational exposure data  $(1x10^{-4} \text{ mg/kg/day}; \text{ USEPA}, 1984e; \text{ USEPA}, 1986c)$ . Inhalation risks are assessed in this report using the more conservative AIC for inorganic mercury (above).

The maximum concentration of mercury in airborne dust on site  $(0.14 \text{ ug/m}^3)$  is below the occupational exposure limits for mercury vapor  $(50 \text{ ug/m}^3; \text{ OSHA}, 1989)$ . This maximum

concentration on site is also below the AAL for inorganic mercury (0.24  $\text{ug/m}^3$ ) and approximately equivalent to the AAL for mercury vapor (0.12  $\text{ug/m}^3$ ; WDOE, 1988).

Mercury and compounds have been given a weight-of-evidence classification for carcinogenicity of D, not classified as to human carcinogenicity, on a scale of A to D. The rationale behind this classification is the lack of human data and the judgement that the available animal data are inadequate.

# 8. Nickel

In the indicator chemical selection step, application of worst-case exposure assumptions for ingestion of soil at the Asarco site produced an estimated dose of nickel that is an order of magnitude lower than the EPA AIC (USEPA, 1986c). As the worst-case dose would be well below the threshold for non-carcinogenic effects, oral non-carcinogenic risks were not quantitatively estimated in this assessment. At this time, there is no evidence to suggest that ingested nickel is carcinogenic (USEPA, 1988a; ATSDR, 1987d). Therefore we have assumed that ingestion of nickel at the site will not contribute to the cancer risk from nickel exposure.

There are no conclusive data available to indicate which form of nickel is present at the Asarco site. The carcinogenic potency of inhaled nickel varies with its form, with nickel subsulfide the most carcinogenic. 100% of the nickel at the Asarco site is conservatively assumed to be present as nickel refinery dust, which includes the carcinogenic nickel subsulfide.

Inhalation of nickel is associated with respiratory tract cancer in nickel refinery workers. The inhalation potency factor of 1.7 (mg/kg/day)-1 developed by EPA is based on the incidence of respiratory cancer in workers exposed to nickel refinery dust containing nickel subsulfide (USEPA, 1988a). Quantitative data concerning the uptake of nickel by the respiratory tract are not available (ATSDR, 1987d). Because respiratory absorption efficiency is completely dependent on the characteristics of the dust particles respired, an accurate determination of the percent of nickel actually absorbed cannot be made. 100% absorption efficiency is therefore conservatively assumed.

The maximum annual average concentration of nickel in air on site exceeded the AAL for nickel  $(0.002 \text{ ug/m}^3)$  by a factor of three (Table II-D). The PEL for nickel sulfide is 1,000 ug/m<sup>3</sup>, which is ten thousand times greater than the eight-hour maximum levels on site.



#### 9. Polcyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbon (PAH) mixtures have been shown conclusively to be carcinogenic to humans; however, no data on the carcinogenicity of individual PAH compounds to humans are available.

Fourteen individual PAHs have been shown to be carcinogenic in studies in laboratory animals with tumors observed in multiple organs after inhalation, ingestion, or dermal exposures. In addition to these fourteen probable human carcinogens, the EPA has classified nine other PAHs as possible human carcinogens. The carcinogenic effects of PAHs are largely associated with the high-molecular-weight species (HPAHs) (IARC, 1983).

EPA's estimates of the cancer potency for PAHs is based on studies of benzo[a]pyrene (USEPA, 1984b). Benzo[a]pyrene (B[a]P) is one of the most well-studied PAHs and is considered the most potent of the carcinogenic PAHs.

The oral potency factor for B[a]P is based on the incidence of stomach tumors (squamous cell papillomas and carcinomas) in mice exposed to B[a]P in the diet. The inhalation potency factor is based on the incidence of respiratory tumors in male hamsters exposed to B[a]P by inhalation. A dermal potency factor was not developed (USEPA, 1984b). Therefore, we are unable to quantitatively evaluate the risk of skin cancer from B[a]P. It is inappropriate to use the oral or inhalation potency factors to evaluate a systemic dose absorbed through skin, because the EPA criteria are based on the rate of incidence of stomach and respiratory tumors, respectively.

#### 10. Polychlorinated Biphenyls (PCBs)

PCBs have not been shown to be carcinogenic to humans, although they have been shown to cause liver tumors in rodents via ingestion. In the study used by EPA to develop the PCB potency factor, PCB exposure did not shorten the life span of laboratory rats, nor did it increase the overall incidence of rat tumors (Kimbrough et al., 1975). However, the treatment increased the incidence of liver tumors late in life while suppressing other types of tumors. PCBs have been shown to decrease the tumor incidence in experimental animals if administered prior to exposure to other carcinogens.

The EPA oral potency factor for PCBs is based on the combined incidence of hepatocellular carcinoma and neoplastic nodules in female rats exposed to PCBs in the diet (USEPA, 1986b). Risks from exposure via dermal contact are evaluated in this assessment using the



EPA oral potency factor and appropriate absorption factors, because the potency is based on systemic effects rather than on tumors formed at the site of entry (USEPA, 1986b).

# 11. Dibenzofuran

Dibenzofuran was detected in soils at a few locations on the Asarco site (mean = 0.54 ppm). There are little data available on the toxicity of this compound, although the toxicological properties of dibenzofurans as a chemical class have been extensively studied. Therefore, the risks associated with exposure to this chemical cannot be quantified. Our evaluation of its toxicity is qualitative, and centers on the relationship of the unsubstituted congener to the highly toxic polychlorinated dibenzofurans.

#### a. Toxicity

Dibenzofurans and dibenzo-p-dioxins are structurally-related compounds that produce similar patterns of biological and toxicological responses. Limited experimental data, in addition to strong structure/activity relationships for in vitro and in vivo toxic effects, indicate that many of the 135 polychlorinated dibenzofuran congeners may evoke toxicologic responses similar to that of the polychlorinated dibenzo-p-dioxins (Bellin and Barnes, 1985; Safe et al., 1985). The dibenzofurans vary greatly in toxic potency, and most of the congeners have not been adequately tested (DOHS, 1985; Poland and Knutson, 1982; Poland et al., 1982).

The unsubstituted dibenzofuran detected at the Asarco site apparently does <u>not</u> produce the toxic or mutagenic effects associated with some of the structurally similar chlorinated dibenzofurans (Poland and Knutson, 1982; Poland et al., 1982; Safe et al., 1985; Bellin and Barnes, 1985; DOHS, 1985). Because this congener does not have the apparently requisite lateral halogen substituents, it will in all probability not bind to the cytosolic receptor protein which mediates the toxic effects associated with polychlorinated dibenzofurans and dibenzo-p-dioxins.

## b. Carcinogenicity

Currently, there are little data available on the carcinogenic potential of the dibenzofuran chemical class. A detailed review of the current literature produced no evidence that the unsubstituted dibenzofuran detected at the Asarco site is carcinogenic to animals or humans (USEPA, 1986c; USEPA, 1988a; Safe et al., 1985; Huff et al., 1980; Bellin, 1985; Kociba and Cabey, 1985; Poland and Knutson, 1982; Poland et al., 1982; DOHS, 1985).



The California Department of Health Services (DOHS) concluded in a 1985 report (DOHS, 1985) that polychlorinated dibenzofuran isomers containing greater than four chlorines should be considered potential human carcinogens. This conclusion was based on the evidence that 2,3,7,8-TCDD is an animal carcinogen, and on the structure/activity relationships between the presence of lateral chlorine substituents and binding with the cytosolic receptor protein (DOHS, 1985). Such an inference may not be sound, as it has not been shown that the cytosolic receptor protein is associated with any carcinogenic response. The DOHS did not make a determination of the carcinogenic potential of dibenzofuran congeners with less than four chlorines, such as the unsubstituted dibenzofuran present at the Asarco site. EPA does not consider unsubstituted dibenzofuran to be carcinogenic.

# c. Mutagenicity

The Salmonella mutagenesis assay is based on observations of reversion mutations in mutant strains of salmonella bacteria. In a recent compilation of data from various studies of chlorodibenzo-p-dioxins and furans, no mutagenic response from unsubstituted dibenzofuran was observed in 8/8 strains of Salmonella sp. (Kociba and Cabey, 1985).

Based on our review of the literature, there is no evidence to suggest that unsubstituted dibenzofuran is toxic, carcinogenic, or mutagenic at the levels detected at the Asarco site.

#### 12. Dibenzothiophene

Dibenzothiophene is a colorless crystalline solid which occurs in petroleum oils and is used in the production of cosmetics and pharmaceuticals (Sax and Lewis, 1987). Very little information is available on the toxicological properties of this chemical. In a review of TOXLIT database, this chemical reported to be the main ingredient responsible for the rose scent in rose oil (NLM, 1989). In this same database, one study of polycyclic aromatic sulfur heterocycles, including dibenzothiophene, found that these compounds demonstrate very weak or no mutagenic activity (NLM, 1989). Dibenzothiophene is also inactive as a carcinogen (USEPA, 1989b). Because there is no overt reference to the toxicity of dibenzothiophene in the literature, and as it is used in cosmetics and pharmaceuticals, one may expect any health risks associated with low-level exposure to dibenzothiophene to be minimal.



#### 13. meta-Nitroaniline

At the Asarco site, m-nitroaniline was detected in 5% of the soil samples. The mean concentration was 1.24 ppm, and the upper 95% level was 1.41 ppm. A search of the National Library of Medicine's Medline databases (RTECS, GENETOX, AQUIRE, IRIS, HSD, and CASR) revealed no dose-response information for this compound. The evaluation of this chemical is qualitative because of insufficient toxicological data.

### a. Toxicity

m-Nitroaniline is readily absorbed through intact skin. Its vapors can be toxic (Beard and Noe. 1981). Although occupational studies have documented that acute exposure to high levels of m-nitroaniline may cause methemoglobinemia and chronic exposure to concentrated amounts can result in liver damage (Merck, 1988; Beard and Noe, 1981), the evidence is insufficient to determine whether or not the low levels present at the Asarco site would produce adverse effects.

# b. Carcinogenicity

m-Nitroaniline and the other nitroaniline isomers are not reported to be carcinogenic in the current scientific literature (Beard and Noe, 1981; USEPA, 1986c; USEPA, 1988a).

# c. Mutagenicity

The mutagenicity of m-nitroaniline in the Ames Salmonella assay was reported by Shimizu and Yano (1986) as part of a study of the structure/mutagenicity relationships of 37 mononitrobenzene derivatives. Five strains of Salmonella typhimurium were used for the detection of frameshift mutations and base-pair substitution mutations. Chemicals inducing more than twice the number of revertant colonies as the control (DMSO) plate were considered to be mutagenic.

m-Nitroaniline was most mutagenic in the frameshift strains; however, some base-pair substitution strain mutagenicity was observed at high doses (Shimizu and Yano, 1986). Shahin has also reported the mutagenicity of m-nitroaniline in three strains of Salmonella typhimurium (Shahin, 1985). M-nitroaniline has been reported to be mutagenic in the "rec" assay as well, which is a mutagen screening assay performed with strains of Bacillus subtilis (Shimizu and Noe, 1986).

Other researchers have reported that m-nitroaniline is mutagenic only under certain test conditions, such as the presence of external enzyme systems (Loew, et al. 1979). Bioreduction of the nitro group to an active intermediate is assumed to be the mechanism of bioactivation (Chiu, et al. 1978).

In summary, m-nitroaniline does not appear to be present at the site at levels that would be of potential health concern to current or future residents. The information available indicates that m-nitroaniline is not associated with carcinogenic effects and, therefore, it will not add to the overall carcinogenic risk for the site.



# V. RISK CHARACTERIZATION

According to an EPA guidance manual (USEPA, 1986c), the "acceptable" range of carcinogenic risk is 10-4 to 10-7, or a chance of between one in 10,000 to one in 10,000,000 of developing cancer (but not necessarily dying from it) due to exposure to carcinogens. An upper-bound estimate of risk in this range means over lifetime (76.2-year) exposure to given chemical concentrations, a person experiences a maximum increased chance of from one out of ten-thousand to one out of a million of developing cancer. This report follows these conservative federal guideline in risk levels for the site. To calculate a total cancer risk for the site, risks for all chemicals with carcinogenic effects are summed for all relevant routes of exposure.

Non-carcinogenic health risks are evaluated separately from carcinogenic risks. Unlike chemicals with carcinogenic effects, non-carcinogenic chemicals are assumed by the EPA to have a threshold dose level below which no adverse effects are observed. Health risks of these chemicals are therefore evaluated by comparing the calculated daily dose resulting from site exposure to the EPA estimate of "acceptable" daily intake for chronic exposure (AIC; USEPA, 1986c) or more recently the verified reference dose (RID). These criteria, which are discussed in the toxicity assessment section, approximate the dose that is not expected to result in any adverse health effects over long-term exposure. Risks of non-carcinogenic chemicals that act by toxicologically similar mechanisms should be added. Several metals at the site have the potential to affect the same target organ, possibly by similar mechanisms. This interaction is discussed separately, below.

A range of risk estimates are given for both carcinogens and non-carcinogens according to the range of possible exposure assumptions from "typical" to "worst-case". "Worst-case" risks were calculated using worst-case exposure assumptions and exposure concentrations from the upper 95% level of the sampling data. "Typical" risks were calculated using more realistic (although still conservative) exposure assumptions and the mean soil concentration for site chemicals. The "worst-case" exposure condition gives the most conservative results and thus is unlikely to underestimate the risk, but may significantly overestimate risk. The effect of these assumptions on the results are discussed in more detail in the uncertainty section (Appendix E).

The following sections discuss the results of the risk characterization for carcinogenic and non-carcinogenic chemicals.



#### A. CARCINOGENIC RISKS

Tables V-A and V-B list the carcinogenic risks for the indicator chemicals under "typical" and "worst-case" exposure assumptions for the populations at risk. Carcinogenic risks are presented as the lifetime incremental upper-bound risk of developing cancer as a result of being exposed to these chemicals under the assumed conditions. These risks are presented for each chemical and as a total for all exposure routes of concern for each of the two hypothetical site-use scenarios and for offsite residents as recommended by USEPA (1986c).

# 1. Comparison of Risks Among Carcinogenic Chemicals

Arsenic accounted for 99% of the site risk under all scenarios considered. (Note: risks shown by Tables V-A and V-B are rounded to a number followed by an order of magnitude, e.g., 1 x 10-6, as recommended by USEPA (1986c). As a result, percentages of risk calculated from these tables may differ slightly because of roundoff error). The total risk due to arsenic was 10-1 to 10-3. The chemicals associated with the next highest risk level were HPAHs (10-3 under "worst-case" exposure). The other chemicals with carcinogenic effects (cadmium, chromium, nickel, and PCBs) have risks within EPA guidelines (10-4 to 10-7). Figures 3 and 4 depict the site risks using a normal scale to show actual proportions and a log scale for readability of values. As can be seen on the normal scale, the proportion of risk attributed to arsenic is far greater than that of any of the other chemicals combined.

Arsenic also accounted for 99% of the risk for offsite inhalation of fugitive dust. Risks for chromium were within the 10<sup>-4</sup> to 10<sup>-7</sup> range in "acceptable" risk (USEPA, 1986c). Cadmium and nickel were associated with 10<sup>-6</sup> risks via inhalation.

Carcinogenic risks associated with the various exposure pathways for the indicator chemicals are discussed below in order of highest to lowest risk at the site.

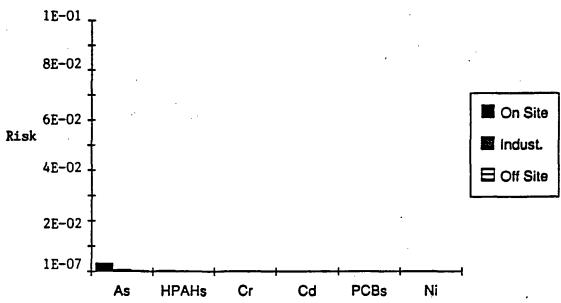
#### a. Arsenic

Arsenic is the dominant source of risk for the populations and site uses considered. The soil ingestion pathway was associated with the greatest arsenic risks under "worst-case" exposure assumptions for onsite residents. Risks by this pathway were about 10 times greater than risks associated with home-grown vegetable consumption and about 80 times the risks via inhalation.

Figure 3

Total Carcinogenic Risk - "Typical" Exposure
Conditions (Normal Scale)





Total Carcinogenic Risk - "Typical" Exposure Conditions (Log Scale)

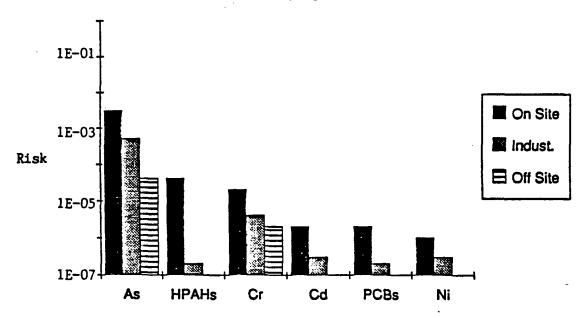
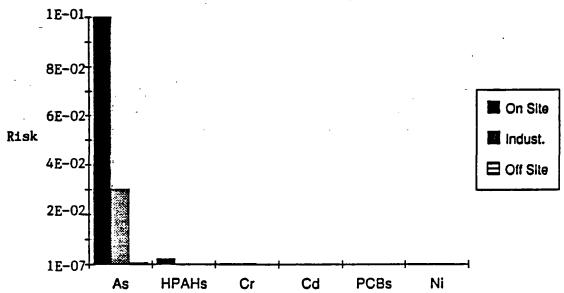


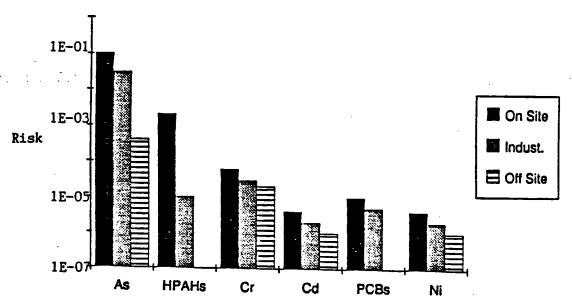
Figure 4

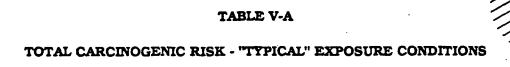
Total Carcinogenic Risk - "Worst-Case" Exposure
Conditions (Normal Scale)





Total Carcinogenic Risk - "Worst-Case" Exposure Conditions (Log Scale)





CHEMICAL	HYPOTHETICAL ON SITE Residential	HYPOTHETICAL ON SITE Industrial	CURRENT OFF SITE Residential	
<b>.</b>			45.05	<u></u>
Arsenic	3E-03	5E-04	4E-05	
HPAHs	4E-05	2E-07	••	
Chromium	2E-05	4E-06	2E-06	
Cadmium	2E-06	3E-07	1E-07	
PCBs	2E-06	2E-07		-
Nickel	<u>1E-06</u>	<u>3E-07</u>	<u>1E-07</u>	-
Total Risk	3E-03	5E-04	4E-05	

TABLE V-B

TOTAL CARCINOGENIC RISK - "WORST-CASE" EXPOSURE CONDITIONS

O. T. O. C.	HYPOTHETICAL	HYPOTHETICAL	CURRENT
CHEMICAL	ON SITE Residential	ON SITE Industrial	OFF SITE Residential
Arsenic	1E-01	3E-02	4E-04
HPAHs	2E-03	1E-05	••
Chromium	6E-05	3E-05	2E-05
Cadmium	4E-06	2E-06	1E-06
PCBs	1E-05	5E-06	
Nickel	<u>4E-06</u>	<u>2E-06</u>	<u>1E-06</u>
Total Risk	1E-01	3E-02	4E-04

<sup>--</sup> Chemical is not of concern via inhalation of fugitive dust.



Soil ingestion was also associated with the greatest risks under "typical" exposure conditions; differences in risk between this pathway and the other pathways were by a factor six. Risks due to vegetable ingestion were not included in calculations of risks for arsenic because arsenic concentrations at the site exceeded the upper limit for plant yield.

Under the industrial use scenario, risks associated with soil ingestion were 60 times greater than those associated with inhalation of arsenic in dust. Inhalation of arsenic in dust would result in risks of  $10^{-3}$  to  $10^{-4}$  for workers. By comparison, the eight-hour maximum concentration of arsenic in the air  $(4.6 \text{ ug/m}^3)$  is below the occupational standard (PEL) for inorganic arsenic  $(10 \text{ ug/m}^3)$ : Table IV-C).

#### b. HPAHs

Risks were calculated for exposure to this group of chemicals by soil ingestion. (Inhalation was determined to be a less significant route of exposure; see Exposure Assessment, Section II.) For the residential site-use scenario, "worst-case" and "typical" risks ranged widely from 10-3 to 10-5 because of the large variance in samples taken at the site which increased the upper 95% sample level use for "worst-case" calculations. PAHs were localized to a few "hot spots" on site. Risks for workers were 10-6 and lower.

As noted previously, almost half of the average HPAH concentration on site is made up of pyrene and fluoranthene, which the available evidence indicates are not carcinogenic (IARC, 1983). Total HPAHs are evaluated assuming they all have the same potency as benzo(a)pyrene, which makes up only 9% of the average concentration of HPAHs. This conservative approach is thought to more than compensate for any cocarcinogenic effect of PAHs in mixtures (USEPA, 1984f).

#### c. Chromium

Carcinogenic risks by inhalation were  $10^{-4}$  to  $10^{-5}$  for "worst-case" and "typical" exposure conditions, assuming lifetime exposure on-site. "Worst-case" and "typical" risks for workers were an order of magnitude less than corresponding risks for the residential scenario. Inhalation risks to offsite populations are within EPA guidelines ( $10^{-4}$  to  $10^{-7}$ ).

# d. Cadmium

Carcinogenic risks were calculated for inhalation of cadmium in dust from the site. The risks associated with this metal were on the order of 10-6 or less for all populations and



site use scenarios. For workers, the eight-hour maximum concentration in air is four orders of magnitude-lower than the PEL for cadmium.

#### e. PCBs

Risks for the low and infrequent levels of PCBs detected at the site ranged from 10-5 to 10-6 for residential site-use and 10-6 to 10-7 for the industrial site-use scenario. Levels of these compounds are within state and federal guidelines.

#### f. Nickel

Like chromium and cadmium, nickel is reported to have carcinogenic effects primarily by inhalation. Cancer risks for this route of exposure were 10-6 or less for all site-use and exposure scenarios.

# 2. Comparison of Carcinogenic Risks Among Exposed Populations

Under the "typical" exposure scenario, the lifetime cancer risk on site is 10-3 for a hypothetical resident living on the site and assuming current soil conditions. The "worst-case risk is 10-1 for a hypothetical individual who resides at the site 24 hours a day for 76.2 years. This calculation was made assuming extremely conservative conditions which are unlikely to occur in reality. Almost all of this risk is due to arsenic. With the exception of arsenic, the risks are almost all within EPA guidelines for allowable exposure under current conditions.

By comparison, if the site were to be developed for light industry or commercial use, the lifetime the "typical" risks for workers would be between 10-3 to 10-4. If the site were used for heavy industry, the worst-case lifetime risk of developing cancer would be 10-2. Table IV-C compares the eight-hour maximum levels in air at the site to the occupational exposure limits for the chemicals of concern by the inhalation route (arsenic, cadmium, chromium, copper, lead, nickel). All inhalation exposures would be below the occupational limits of exposure.

Current offsite risks associated with inhalation of metals in fugitive dust are 10<sup>-4</sup> at the location of highest impact on adjacent residential or school property at the site boundary ("worst-case"). This risk level is at the upper limit of federal guidelines for allowable exposure. The cancer risk is about an order of magnitude less (10<sup>-5</sup>) for an individual who lives 0.4 km west of the location of highest impact and leaves the area for ten hours a day,



five days a week from ages 6 to 76.2 years old ("typical"; i.e., goes to school or work in an area of lower concentration).

Deposition of arsenic in fugitive dust off site is estimated to increase residential soil concentrations by 4.7 mg/kg each year at the location of maximum impact, assuming no loss of arsenic from the soil. This amount represents approximately 1% of the geometric mean soil concentration and 0.3% of the upper 95% level within a half a mile of the site (reported by the Endangerment Assessment; Black and Veatch, 1988). The additional risk from ingestion of arsenic deposited in soil over a lifetime would be 10-4 at the location of maximum impact off site. At 0.4 km from the western boundary of the site, annual deposition drops off to 0.0028 g/m²/year. The excess risk over a lifetime at this location would be 10-6 for soil ingestion exposure under "typical" conditions.

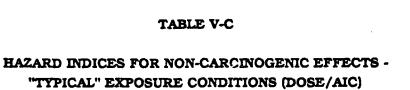
By comparison, risks calculated for the soil ingestion pathway for residents within a half-mile of the smeller have been estimated to be 10-2 to 10-3 (Black and Veatch, 1988). Although 10-4 represents the upper limit of EPA guidelines for allowable exposure, it is of interest to note that the incremental risk to offsite residents due to deposition of arsenic from fugitive dust at present onsite soil conditions is small relative to the present risks due to offsite soil levels of arsenic.

#### **B. NON-CARCINOGENIC RISKS**

Tables V-C and V-D list the non-carcinogenic risks for the indicator chemicals under the hypothetical land use scenarios. Non-carcinogenic risks are presented as a hazard index which is the ratio between the calculated dose and the AlC given in Table IV-A. Ratios exceeding unity (one) indicate doses that exceed the acceptable level; ratios less than one are not expected to cause adverse health effects according to current EPA guidelines (USEPA, 1986c).

## 1. Comparison of Non-carcinogenic Risks Among Chemicals

The primary chemicals of concern for non-carcinogenic effects are lead which exceeds the oral AIC by 56 (60) times, and copper and antimony, which exceed their oral AIC by 30 times under "worst-case" conditions. By comparison, under the "worst-case" industrial site-use scenario, the dose for lead exceeds the AIC by five times.



OVERNA CAN		HETICAL	CURRENT
CHEMICAL  By Route of Exposure	Residential	SITE Industrial	OFF SITE Residential
Oral			
Lead	4E+00	1E-01	•• A TIEL
Antimony	9E-01	4E-02	•• .J
Copper	8E-01	4E-02	•÷
Cadmium	6E-01	3E-02	
Mercury	3E-01	1E-02	•••
Inhalation			
Mercury	5E-01	1E-01	1E-01
Lead	1E-01	2E-02	1E-02
Copper	5E-03	1E-03	4E-04

<sup>--</sup> Route is not of potential health concern according to best available data (Black and Veatch, 1988; USEPA, 1988a).



# TABLE V-D

# HAZARD INDICES FOR NON-CARCINOGENIC EFFECTS - "WORST-CASE" EXPOSURE CONDITIONS (DOSE/AIC)

	НҮРОТ	CURRENT		
CHEMICAL	ON	SITE	OFF SITE	
By Route of Exposure	Residential	Industrial	Residentia	
Oral				
Lead	6E+01	5E+00		
Antimony	3E+01	3E+00		
Copper	3E+01	3E+00		
Cadmium	1E+01	1E+00	••	
Mercury	6E+00	6E-01	••	
Inhalation				
Mercury	1E+00	7E-01	4E-01	
Lead	3E-01	1E-01	8E-02	
Copper	3E-02	7E-03	3E-03	

<sup>--</sup> Route is not of potential health concern according to best available data (Black and Veatch, 1988; USEPA, 1988a).



#### a. Lead

Ingestion, particularly of soil, is the primary route of potential health concern. Soil ingestion results in a dose that is an order of magnitude greater than the dose due to ingestion of vegetables grown at the site. Because lead levels at the site were not determined to be phytotoxic; however, the total dose includes both soil and vegetable ingestion pathways (Table V-C and V-D). The non-carcinogenic risk associated with soil ingestion is one to two orders of magnitude greater than risks associated with inhalation.

Lead levels under "worst-case" and "typical" exposure assumptions for site residents would result in doses that exceed the AIC by 56 and four times, respectively. For workers, the oral dose exceeded the AIC by five times for those in heavy industry ("worst-case"), whereas the oral dose was below the AIC for those in light industry ("typical"). Thus, potential lead exposure is not predicted to be unacceptable for this latter population.

Exposure to lead by inhalation of dust is not expected to result in exposure above federal and state guidelines for onsite or offsite populations. The dose is highest for hypothetical site residents, for whom the "worst-case" dose is a tenth of the inhalation AIC.

## b. Antimony

Ingestion of this metal is associated with the next highest non-carcinogenic risks (along with copper). "Worst-case" doses for the residential scenario are 30 times the AIC, whereas "typical" doses are below the AIC. Risks due to antimony were an order of magnitude lower for the industrial use scenarios. Light industry or commercial use of the site is not expected to result in unacceptable exposure.

#### с. Соррет

Levels of copper in site soils are likely to be phytotoxic. The magnitude of the dose via the vegetable ingestion pathway is similar to that for soil ingestion. The hazard indices presented in Tables V-C and V-D include soil ingestion but not vegetable ingestion, because the mean soil concentration of copper at the site exceeded the phytotoxicity level (1,000 ppm). "Typical" exposure for hypothetical residents is associated with a dose below the AIC for soil ingestion and two times the AIC for soil and vegetable ingestion. The hazard index for "worst-case" ingestion of both soil and vegetables would be 40 times the AIC.



Under the industrial scenario, "worst-case" exposure by soil ingestion slightly exceeds the acceptable level of exposure (three times the AIC). "Typical" industrial exposure would result in a dose less than the AIC.

Inhalation of copper in dust by residents or workers on site or by current offsite residents is not expected to result in unexpected exposure given the results modeled by TRC (1988). The inhalation dose for residents is almost two orders of magnitude below the AIC. As for lead, above, "worst-case" and "typical" exposure assumptions, and hence risks for the most sensitive age group, are the same.

#### d. Cadmium

Exposure via home-grown vegetables is potentially the most important pathway of concern for cadmium because of the high proportion of plant uptake and accumulation of cadmium from soil. The "worst-case" dose calculated for vegetable ingestion is five times the soil ingestion dose for the most sensitive age group (zero to one-year-old). However, the upper 95% level of cadmium in site soils (256 ppm) is likely to inhibit vegetable growth for "worst-case" soil conditions. Consequently, the hazard indices presented in Tables V-C and V-D do not include ingestion of vegetables in calculating the oral dose. The "worst-case" oral dose for site residents would be 65 times the AIC instead of 11 times if ingestion of vegetables were possible at the cadmium levels present at the site. For "typical" exposure, the dose for soil ingestion is below the AIC. The combined soil and vegetable ingestion dose is eight times the AIC. Although the average cadmium level in soil (67 ppm) is not as likely to inhibit vegetable growth, high concentrations of associated metals in soil, such as arsenic, will prevent growth of vegetables and additional exposure to cadmium by this pathway.

Risks to hypothetical site residents and offsite populations due to inhalation of cadmium are 10-6 and below, which is within state and federal guidelines.

"Worst-case" exposure for workers barely exceeded the oral AIC for cadmium. Inhalation risks are 10-6 and less.

# e. Mercury

Of the indicator chemicals, mercury presents the lowest non-carcinogenic risk by ingestion at the site, regardless of its possible chemical forms. The "typical" dose is below the AIC for inorganic or organic mercury in all exposed populations. The "worst-case" dose for hypothetical site residents is six times the AIC. Thus, even under the highly unlikely



assumption that the concentration of mercury in soils at the site is the most toxic form (methylmercury), the upper-bound risk is no more than six times the allowable dose under "worst-case" hypothetical residential exposure: "Worst-case" exposure via ingestion for hypothetical workers on site is less than the EPA allowable dose level.

Average concentrations of mercury in site soils were judged to be phytotoxic for vegetables (greater than 50 ppm). If vegetables could be grown at the site, the vegetable ingestion dose would be about twice that via soil ingestion.

Exposure via inhalation of mercury in fugitive dust was conservative assessed using an AIC that is based on mercury vapor, the more toxic form is likely to be in dust. Using this criterion, exposure to mercury by this pathway is not expected to result in adverse effects under "worst-case" assumptions for any of the populations.

# 2. Potential Additive Effects of Metals

Chronic exposure to lead, cadmium, and mercury has the potential to result in adverse effects on similar target organs, possibly by similar mechanism. All three metals have similar effects on the kidney. In addition, lead and mercury both have central nervous system effects. To be conservative, non-carcinogenic risks of these metals are added according to EPA guidelines (USEPA, 1986c).

Because non-carcinogenic risks for mercury and cadmium are lower than for lead, the total metals risk of these chemicals is similar to that of lead alone for "typical" soil ingestion exposure. Total risk and the risk of lead alone are each four times the EPA allowable dose level for hypothetical residents and ten times less than the allowable dose for the industrial workers. [Note: calculations using values in Table V-C may differ slightly due to round-off error.] Under "worst-case" exposure assumptions, however, the total risk is 70 times the allowable dose, whereas lead alone is 60 times. The total "worst-case" risk of the three metals for the industrial scenario is seven times the allowable dose, whereas the risk of lead alone is five times the allowable dose.

Lead and mercury both have the potential for similar target organ effects by inhalation. The addition of lead and mercury risks to estimate possible additive effects of these metals would result in a combined hazard index (estimated dose/allowable dose) that would exceed unity by less than two times under "worst-case" exposure assumptions for hypothetical site residents. The combined hazard index would not exceed unity for the other scenarios or for any of the scenarios under "typical" exposure assumptions.



# 3. Comparison of Non-carcinogenic Risks Among Exposed Populations

The zero to one-year-old age group of onsite residents would be at greatest risk for adverse non-carcinogenic effects. Although this age group has lower ingestion and inhalation rates than the one to six-year-old group, the much smaller body weight of the younger group results in a higher dose for infants. Non-carcinogenic risks are about ten times greater for residential as opposed to industrial uses of the site.

Under "typical" exposure assumptions for hypothetical children residing at the site, only lead exceeded the acceptable dose level for chronic exposure (AIC). Under "worst-case" exposure assumptions for hypothetical site residents, all chemicals examined (antimony, cadmium, copper, lead) resulted in doses by ingestion that exceed their AIC by 10 to 60 times. Based on the sampling and modeling results, ingestion presents the highest risks for residential and industrial site-uses.

Non-carcinogenic risks for offsite residents were considered for inhalation of metals in fugitive dust. None of the indicator chemicals with an inhalation AIC (lead, copper, and mercury) exceeded their criterion for non-carcinogenic risks.



# VI. SUMMARY AND CONCLUSIONS

Metals, including antimony, arsenic, cadmium, chromium, copper, lead, mercury, and nickel, are the most prevalent chemicals of concern at the site. A few organic chemicals of concern were also detected in some locations, although they are distributed in infrequent "hot-spots".

The major determinant of carcinogenic risks for the site is arsenic, primarily via ingestion, assuming no remediation of the soil levels. Risks are highest for the hypothetical residential use scenario ( $10^{-1}$  to  $10^{-3}$ ) and about an order of magnitude lower for industrial use of the site.

Risks to offsite residents due to inhalation of carcinogenic metals in fugitive dust are approximately 10-4 to 10-5 for "worst-case" to "typical" exposure. Based on "worst-case" calculations, deposition of arsenic in fugitive dust is not expected to increase the lifetime risk to offsite residents measurably above current risks calculated for soil ingestion. Offsite risks due to ingestion of arsenic in soil have been estimated to be approximately 10-2 to 10-3 (Black and Veatch, 1988).

Despite this relatively high risk (one-in-a-hundred to one-in-a-thousand), epidemiological studies of the surrounding community have not shown statistically significant increases in morbidity or mortality relative to the general population (summarized by Black and Veatch 1988). Because skin cancer or precancerous dermatological effects have not been studied in the surrounding community, the skin cancer risk due to ingestion of arsenic cannot be evaluated at this time. Epidemiological studies of lung cancer mortality have not shown any statistically significant increases due to inhalation of arsenic. The cancer risks estimated by risk assessment, however, are risks of developing cancer but not necessarily dying. Finally, because few people are likely to fit the conservative exposure assumptions used in risk assessment (e.g., continuous lifetime exposure), the risk estimates are likely to overestimate actual risks for most residents near the site.

The major non-carcinogenic risk is ingestion of lead. Under "typical" exposure conditions, non-carcinogenic risks exceed acceptable levels mainly for hypothetical onsite residents exposed to lead. Secondarily, copper and antimony are also of concern under "worst-case" exposure assumptions. Assuming that children are living at the site with present soil conditions, ingestion of lead in soil is conservatively estimated to result in a dose that is almost 60 times the "acceptable" dose under "worst-case" conditions and four times the "acceptable" dose under "typical" conditions.



By comparison, exposure for workers at the site would result in a "worst-case" dose for lead of five times the AIC. Non-carcinogenic risks via inhalation of lead, mercury, or copper by onsite or offsite populations are not expected to exceed state and federal guidelines for allowable exposure.

These estimates of risks for exposure to lead at the site are probably conservative given the lack of evidence that increased lead in soils has resulted in increased blood lead levels in children living mear the site. Blood lead levels of school children living within a mile of the smelter apparently were not elevated by the increased soil lead levels in this area (average = 1300 ppm; Glass, 1984). A conservative approach is justified, however, given the higher lead soil concentrations on site (average = 3,800 ppm) and the growing evidence indicating adverse effects in children at lower blood lead levels than previously believed to be safe (USEPA, 1988b).

Estimates of combined risks for lead, cadmium, and mercury were performed as recommended by USEPA (1986c) for chemicals with similar toxic mechanisms. Although it is not certain that these metals act by completely similar mechanisms, their additive effects were conservatively assessed because they potentially affect similar target organs. In general, the risks via ingestion of cadmium and mercury are small relative to those of lead. As a result, the total risk is similar to that of lead, increasing slightly (1.2 to 1.4 times) primarily under "worst-case" assumptions. By inhalation, additive effects of mercury and lead are of concern. "Worst-case" exposure to mercury and lead exceeds the allowable dose level by less than two times for the most conservative site use (hypothetical residential). Thus, the additive effects these three metals are small relative to the risk of certain individual metals.

In conclusion, "typical" risks are ten times less than "worst-case" risks for hypothetical residential or industrial uses of the site. Residential use of the site would require reduction of primarily arsenic and secondarily lead and HPAHs. The other indicator chemicals are within allowable EPA guidelines for "typical" exposure conditions. Industrial use of the site will require reduction of mainly arsenic levels. Levels of other chemicals are within EPA guidelines for "worst-case" carcinogenic risks and "typical" non-carcinogenic risks.

Because many of these chemicals occur along with arsenic in soil, reduction in arsenic levels at the site should reduce exposure to the other chemicals as well. Worst-case offsite arsenic levels on residential areas are within the 10-4 to 10-7 range of target risk recommended by the EPA. Although at 10-4 this level may not be sufficiently protective of sensitive populations, few residents are likely to match the conservative exposure assumptions used for worst-case exposure. Worst-case offsite deposition of arsenic in



fugitive dust poses a very small increase in soil concentration and risk relative to the existing levels off site.

These conclusions are based on conservative assumptions with regard to acceptable public health exposures as outlined by state and federal guidelines.



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## APPENDIX A

INDICATOR CHEMICAL SELECTION



#### APPENDIX A

#### INDICATOR CHEMICAL SELECTION

This appendix provides additional details behind the screening for indicator chemicals, including the calculations and toxicity criteria used to evaluate the chemicals sampled at the site. The first section (A) discusses how chemicals that lacked specific EPA toxicity criteria were evaluated. Many of these chemicals could be evaluated conservatively with criteria of other chemicals with similar structure and greater toxicity. Chemicals that could not be evaluated by the screening because of lack of information are listed at the end of this first section.

The second section (B) presents equations, mean concentrations, calculations and results of the indicator chemical selection process. This section presents the different routes and effects evaluated in the following order (1) Non-carcinogenic via soil ingestion, (2) carcinogenic effects via soil ingestion, and (3) carcinogenic effects of metals via dust inhalation. The complete rationale behind the indicator chemical process as well as the results are discussed in the text of Section II. on Hazard Identification.

#### A. EVALUATION OF CHEMICALS LACKING SPECIFIC EPA TOXICITY CRITERIA

#### 1. Chemicals Assessed with Alternative Criteria

Certain chemicals with limited toxicity information could be grouped together based on similar molecular structure in order to assess their toxicity. Mean soil concentrations for chemicals in each individual group were totaled. Each group was then evaluated with an EPA criterion from a chemical with that particular structure. Half the detection limit was used for chemicals that were not detected. These chemicals are denoted by a "e".

Chemical	Average Concentration (mg/kg)
Chemicai	Average Concentration [mg/kg]

#### PHENOLS

Evaluated risks of phenols using  $1.98 \times 10^{-2}$  (mg/kg/day)<sup>-1</sup> for 2,4,6 trichlorophenol (USEPA, 1986c).

2,4-Dimethylphenol	0.203*
4-Nitrophenol	0.200°
4-Chloro-3-Methylphenol	0.203*



## <u>Chemical</u> <u>Average Concentration (mg/kg)</u>

PHENOLS (continued)	
2-Methylphenol	0.203°
4-Methylphenol	0.203*
2-Nitrophenol	0.203
2-Methyl-4,6-Dinitrophenol	<u>0.990</u> •
	2 20g

#### **PHTHALATES**

Evaluated using bis (2-ethylhexyl) phthalate potency factor of 6.84x10<sup>-4</sup> (mg/kg/day)<sup>-1</sup> (USEPA, 1986c).

Butylbenzylphthalate	0.203°
Di-N-Butylphthalate	0.203°
Di-N-Octylphthalate	<u>0.203</u> °
	0.609

#### **CHLOROBENZENES**

Evaluated using potency factor of 1.7 (mg/kg/day)-1 (USEPA, 1985g).

1,2-Dichlorobenzene	0.203*
1.3-Dichlorobenzene	0.203°
1,4-Dichlorobenzene	0.203°
	0.609

#### **2.6-DINITROTOLUENE**

Evaluated as 2,4-DNT using USEPA (1986c) potency factor 0.31 (mg/kg/day)-1.

#### BIPHENYL

Evaluated as polychlorinated biphenyl using potency factor of 4.34 (mg/kg/day)-1 (USEPA, 1986b).

#### POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)

PAHs were evaluated by summing mean concentrations of the high-molecular-weight PAHs (HPAHs) and assuming that the total was 100% benzo(a)pyrene, one of the most carcinogenic PAHs. Upper 95 percentile levels were also summed in calculating worst-case exposure concentrations for HPAHs. PAHs having three aromatic rings or less are low-molecular-weight PAHs (LPAHs), which tend to be less carcinogenic.



#### POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) (continued)

Chemical	Mean (ppm)	<u>Upper 95% (ppm)</u>
<u>HPAHs</u>		
Benzo[a]anthracene	4.44	32.64
Benzo[a]pyrene	3.59	23.28
Benzo[b]fluoranthene	4.81	<b>24.31</b>
Benzo[g,h,i]perylene	2.04	14.53
Benzo[k]fluoranthene	0.25	0.96
Chrysene	4.85	34.59
Dibenzo[a,h]anthracene	0.52	1.30
Fluoanthene	8.42	55.63
Indeno[1,2,3-cd]pyrene	1.72	12.14
Pyrene	<u>10.96</u>	<u>86,20</u>
	41.60	285.58
<u>LPAHs</u>		
Methylphenanthrene	0.61	
Acenaphthylene	0.25	
Anthracene	1.86	
2-Chloronaphthalene	0.20	
Fluorene	1.42	
2-Methylnaphthalene	1.08	
Naphthalene	2.06	
Phenanthrene	<u>9.57</u>	
	17.05	

### 2. Chemicals Without Quantitative Data

Chemicals that lacked EPA toxicity criteria and could not be evaluated by the indicator chemical screen are listed below along with their mean soil concentrations or half their detection limit. Those in this catagory that were detected at the site were evaluated qualitatively in the indicator chemical selection (Section II) and the toxicity assessment (Section IV)



## 2. Chemicals Without Quantitative Data (continued)

Chemical	Average Concentration (mg/kg)
Detected	
Dibenzothiophene	0.406 (detected in 13%)
Dibenzofuran	0.543 (detected in 18%)
m-Nitroaniline	1.239 (detected in 3%)
Not Detected	
1-Methyl (2-methylethyl) benzene	0.388
Benzyl Alcohol	0.203
Bis (2-chloroethoxy) methane	0.203
Bis (2-chloroisopropyl) ether	0.203
4-Bromophenyl-phenyl ether	0.203
4-Chloroaniline	0.203
2-Chloronapthalene	0.203
4-Chlorophenyl-phenyl ether	0.203
3,3-Dichlorobenzidine	0.393
Hexachlorocyclopentadiene	0.203
2-Nitroaniline	1.008
4-Nitroaniline	1.008

### B. INDICATOR CHEMICAL SCREEN-INGESTION ROUTE

## 1. Non-Carcinogenic Effects by Soil Ingestion

#### Equations:

Calculated Dose-Typical = 1/BW \* SIR TY \* SC \* CF Calculated Dose-High = 1/BW \* SIR HI \* SC \* CF

where: ----

Body Weight (0-1 year old child) Soil Ingestion Rate (worst-case) Soil Ingestion Rate (typical)

Soil Concentration **Conversion Factor** 

BW SIR HI SIR TY SC

10 kg;

**USEPA (1986c)** 500 mg/day; La Goy (1987)

100 mg/day; La Goy (1987)

mg/Kg

CF 1.00E-06

	Mean Soil		Calculated	Dose	Hazaro	i Index
Chemical	Concentration	AIC	Worst-Case	Typical	Worst-Case	Typical
	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(mg/kg/day)	(dose/AIC)	(dose/AIC)
Metals						
Antimony	1.39E+02	4.00E-04	6.93E-03	1.39E-03	1.73E+01	3.46E+00
Barium	2.44E+02	5.10E-02	1.22E-02	2.44E-03	2.39E-01	4.78E-02
Cadmlum	6.69É+01	2.90E-04	3.34E-03	6.69E-04	1.15E+01	2.31E+00
Chromium VI	5.90E+01	5.00E-03	2.95E-03	5.90E-04	5.90E-01	1.18E-01
Copper	1.17E+04	3.70E-02	5.84E-01	1.17E-01	1.58E+01	3.16E+00
Lead	3.81E+03	1.40E-03	1.90E-01	3.81E-02	1.36E+02	2.72E+01
Mercury	7.91E+01	2.00E-03	3.95E-03	7.91E-04	1.98E+00	3.95E-01
Nickel	8.33E+01	2.00E-02	4.17E-03	8.33E-04	2.08E-01	4.17E-02
Selenium	6.40E+01	3.00E-03	3.20E-03	6.40E-04	1.07E+00	2.13E-01
Silver	6.84E+01	3.00E-03	3.42E-03	6.84E-04	1.14E+00	2.28E-01
Thallium	8.10E+00	4.00E-04	4.05E-04	8.10E-05	1.01E+00	2.03E-01
Zinc	1.59E+03	2.10E-01	7.93E-02	1.59E-02	3.77E-01	7.55E-02
Organics**						
AC01	1.04E+00	4.00E+00	5.22E-05	1.04E-05	1.30E-05	2.61E-06
AC02*	2.03E-01	5.00E-03	1.02E-05	2.03E-06	2.03E-03	4.06E-04
AC03°	2.03E-01	3.00E-03	1.02E-05	2.03E-06	3.38E-03	6.77E-04
AC06	9.90E-01	2.00E-03	4.95E-05	9.90E-06	2.48E-02	4.95E-03
AC12	9.90E-01	3.00E-02	4.95E-05	9.90E-06	1.65E-03	3.30E-04
AC13	1.96E-01	1.00E-01	9.80E-06	1.96E-06	9.80E-05	1.96E-05
AC14	1.01E+00	1.00E-01	5.04E-05	1.01E-05	5.04E-04	1.01E-04
AC15*	2.03E-01	1.98E-02	1.02E-05	2.03E-06	5.13E-04	1.03E-04
AC18*	3.92E-01	2.00E-03	1.96E-05	3.92E-06	9.79E-03	1.96E-03
BN05	1.51E+00	2.00E-03	7.54E-05	1.51E-05	3.77E-02	7.54E-03
BN13*	2.03E-01	1.10E+00	1.02E-05	2.03E-06	9.23E-06	1.85E-06
BN15	2.12E-01	2.00E-02	1.06E-05	2.12E-06	5.30E-04	1.06E-04
BN18*	2.03E-01	4.00E-03	1.02E-05	2.03E-06	2.54E-03	5.08E-04
BN28*	2.03E-01	1.30E+01	1.02E-05	2.03E-06	7.81E-07	1.56E-07
BN37*	2.03E-01	8.00E-04	1.02E-05	2.03E-06	1.27E-02	2.54E-03
BN38*	2.03E-01	2.00E-03	1.02E-05	2.03E-06	5.08E-03	1.02E-03
BN39*	2.03E-01	7.00E-03	1.02E-05	2.03E-06	1.45E-03	

### 1. Non-Carcinogenic Effects by Soil Ingestion (cont.)



	Mean Soil		Calculated Dose		Hazard Index	
Chemical	Concentration	AIC	Worst-Case	Typical	<b>Worst-Case</b>	Typical
	(mg/kg)	(mg/kg/day)	(mg/kg/day)	(mg/kg/day)	(dose/AIC)	(dose/AIC)
BN42	2.09E-01	1.50E-01	1.05E-05	2.09E-06	6.97E-05	1.39E-05
BN48*	2.03E-01	5.00E-04	1.02E-05	2.03E-06	2.03E-02	4.06E-03
BN54*	2.03E-01	2.00E-02	1.02E-05	2.03E-06	5.08E-04	1.02E-04
Phthalates*	8.37E-01	2.00E-02	4.19E-05	8.37E-06	2.09E-03	4.19E-04

<sup>\*</sup>not detected in any sample

Shading: The HAZARD INDEX is the ratio between the dose and the AIC. If this number exceeds one, the dose exceeds the AIC and the chemical is selected as an indicator chemical

### 2. Carcinogenic Effects by Soil Ingestion

#### Equations:

Worst-Case Dose = SIR \* SC \* 1/BW \* CF

Worst-Case Risk = Dose \* Potency Slope

where:

Lifetime Soil Ingestion Rate	SIR	200 mg/day**	(Section II)
Soil Concentration	SC	mg/Kg	
Body Weight	BW	70 kg; USEPA (	(1986c)
Conversion Factor	CF	1.00E-06 Kg/mg	

	•	EPA		
•	Mean Soll	Potency		
Chemical	Concentration	Slope	Dose	Risk
<u> </u>	(mg/kg)	(1/mg/kg/d)	(mg/kg/d)	
Metais				
Arsenic	9.78E+03	1,50E+00	2.79E-02	4.19E-02
Organic				
AC15*	2.03E-01	1.98E-02	5.80E-07	1.15E-08
AC16	3.92E-01	4.34E+00	1.12E-06	4.86E-06
BN03*	2.03E-01	5.70E-03	5.80E-07	3.31E-09
BNQ5	1.51E+00	2.30E+02	4.31E-06	9.90E-04
BN13*	2.03E-01	1.10E+00	5.80E-07	6.38E-07
BN15	2.12E-01	6.84E-04	6.06E-07	4.14E-10
BN31*	2.03E-01	3.10E-01	5.80E-07	1.80E-07

<sup>\*\*</sup>see key in the following section for names of the chemicals

## 2. Carcinogenic Effects by Soil Ingestion (cont.)

		EPA		
	Mean Soil	Potency		
Chemical	Concentration	Slope	Dose	Risk
	(mg/kg)	(1/mg/kg/d)	(mg/kg/d)	
BN32	2.14E-01	3.10E-01	6.11E-07	1.90E-07
BN38*	2.03E-01	7.75E-03	5.80E-07	4.50E-09
BN39*	2.03E-01	1.00E-03	5.80E-07	5.80E-10
BN58	8.19E-01	4.34E+00	2.34E-06	1.02E-05
HPAHs	4.15E+01	1.15E+01	1.18E-04	1.36E-03
BN50*	2.03E-01	7.00E+00	5.80E-07	4.06E-06
BN49*	2.40E+01	5.10E+01	6.86E-07	3.50E-05
Phthalates*	6.09E-01	6.84E-04	1.74E-06	1.19E-09
DCB*	6.09E-01	1.70E+00	1.74E-06	2.96E-06
Phenois*	2.21E+00	1.98E-02	6.31E-06	1.25E-07

<sup>• =</sup> not detected

DCB = Dichlorobenzenes

Shading denotes risk exceeding 1E-06

### 3. Carcinogenic Effects by Inhalation On Site

#### **Equations:**

Risk = (IR \* Ambient Concentration \* CF/BW)\* Potency Slope

Inhalation rate

IR

20 m3/day; USEPA (1986c)

Body weight

BW

70 kg:

USEPA (1986c)

Conversion factor

0.001 mg/ug

_ Chemical	Annual Ambient Concent.	24 Hour Ambient Concent.	Potency Slope	Risk Annual	Risk 24-Hour
	(ug/m3)	(ug/m3)			
Arsenic	2.68E-01	3.37E+00	5.DDE+01	3.83E-03	-4.81E-02
Cadmium	2.23E-03	2.81E-02	6.10E+00	3.89E-06	4.90E-05
Chromium VI Nickel	4.56E-03 6.70E-03	5.73E-02 8.43E-02	4.10E+01 1.70E+00	5.34E-05 3.25E-06	6,71E-04 4,09E-05

Shading indicates chemicals that exceed 1E-06 risk.

<sup>\*\*</sup> See Section II on development of this assumption



## KEY TO SAMPLE CODES FOR ORGANIC CHEMICALS

AC01	Benzoic Acid
AC02	2-Chlorophenol
AC03	2.4-Dichlorophenol
AC04	2,4-Dimethylphenol
AC06	2,4-Dinitrophenol
AC07	2-Methylphenol
AC08	4-Methylphenol
AC09	2-Nitrophenol
AC10	4-Nitrophenol
AC11	4-Chloro-3-methylphenol
AC12	Pentachlorophenol
AC13	Phenol
AC14	2.4.5-Trichlorophenol
AC15	2,4,6-Trichlorophenol
AC16	Biphenyls
AC17	Dibenzothiophene
AC18	Dimethylaniline
AC19	Methylphenanthrene
AC20	1-Methyl (2-methylethyl) benzene
BN01	Acenaphthene
BN02	Acenaphthylene
BN03	Aniline
BN04	Anthracene
BN05	Benzidine
BN06	Benzo(a)anthracene
BN07	Benzo(a)pyrene
BN08	Benzo[b]fluoranthene
BN09	Benzolg,h,ilperylene
BN10	Benzo[k]fluoranthene
BN11	Benzyl Alcohol
BN12	bis (2-chloroethoxy) methane
BN13	bis (2-chloroethyl) ether
BN14	bis (2-chloroisopropyl) ether
BN15	bis (2-ethylhexyl) phthalate
BN16	4-Bromophenyl-phenyl ether
BN17	Butyl benzyl phthalate
BN18	4-Chloroaniline



## KEY TO SAMPLE CODES FOR ORGANIC CHEMICALS (Continued)

BN19	2-Chloronaphthalene
BN20	4-Chlorophenyl-phenyl ether
BN21	Chrysene
BN22	Dibenzo[a,h]anthracene
BN23	Dibenzofuran
BN24	1,2-Dichlorobenzene
BN25	1,3-Dichlorobenzene
BN26	1,4-Dichlorobenzene
BN27	3,3-Dichlorobenzidine
BN28	Diethyl phthalate
BN29	Dimethyl phthalate
BN30	Di-n-butyl phthalate
BN31	2,4-Dinitrotoluene
BN32	2,6-Dinitrotoluene
BN33	Di-n-octyl phthalate
BN35	Fluoranthene
BN36	Fluorene
BN37	Hexachlorobenzene
BN38	Hexachlorobutadiene
BN39	Hexachlorocyclopentadiene
BN40	Hexachloroethane
BN41	Indeno[1,2,3-cd]pyrene
BN42	Isophorone
BN43	2-Methylnaphthalene
BN44	Naphthalene
BN45	2-Nitroaniline
BN46	3-Nitroaniline (or m-nitroaniline)
BN47	4-Nitroaniline
BN48	Nitrobenzene
BN49	N-Nitrosodimethylamine
BN50	N-Nitrosodipropylamine
BN51	N-Nitrosodiphenylamine
BN52	Phenanthrene
BN53	Pyrene
BN54	1,2,4-Trichlorobenzene
BN55	2-methyl-4,6-dinitrophenol
BN56	PCBs



EXAMPLE CALCULATIONS



## **EXPOSURE ASSESSMENT FOR ARSENIC**

					-
Assumptions and Parameters					
soil concentration-worst-case	SCw	7.04E+01	mg/g	7.04E+04	ppm
soil concentration-typical	SCt	9.78E+00	mg/g	9.78E+03	ppm
ambient air-worst-case	AW	2.68E-04	mg/m3	2.68E-01	ug/m3
ambient air typical	AT	1.40E-04	mg/m3	1.40E-01	ug/m3
ambient air off site high	WOA	8.00E-05	mg/m3	8.00E-02	ug/m3
ambient air off site typical	AOT	1.10E-05	mg/m3		
ingestion absorption	ING	4.00E-01	ratio		
dermal absorption	DER	0.00E+00	ratio	•	
inhalation absorption	INH	3.00E-01	ratio		
plant uptake leafy	PL	2.60E-03	g soil/g plant		
plant uptake root	PR	6.00E-04	g soil/g plant		
Potency Slope for ARSENIC					•
oral (PSO)	1.65E+00	kg-day/mg			
inhal(PSI)	5.00E+01	kg-day/mg			
CORRECTION FACTORS FOR	SCENARIOS (CF	<del>"</del> )			
On-Site	·	On-Site		Off-Site	

CORRECTION	FACTORS	FOR SCENARIOS (CF	۲:
CONNECTION	PACIONS	FUN SCEIVANIUS IUF	•

On-Site Residential			On-Site Industrial		Off-Site Residential	
Inhalation						
worst-case adult*	<b>CFRIAW</b>	1	CFIIA	0.71	<b>CFOIAW</b>	1
typical adult*	CFRIAT	0.7			CFOIAT	0.7
-child	CFRIC	1	CFIIC	0	CFOIC	1
Soil Ingest-adult	CFRSA	0.5	CFISA	0.36	CFOSA	0
-child	CFRSC	0.5	CFISC	0	CFOSC	0
Veg Ingestadult	CFRVA	1	CFIVA	0	CFOVA	0
-child	CFRVC	1	CFIVC	0	CFOVC	0
Dermaladult	CFRDA	0.5	CFIDA	0.36	CFODA	0
-child	CFRDC	0.5	CFIDC	0	CFODC	0
*Includes ages 6-76.2	voore old					



#### **INTAKE RATES**

Age	Body weight kg (BW)	Soil Ingestion (typical) g/day (SIR)	Soil Ingestion (worst-case) g/day (SIM)	Inhalation rate m3/day (IR)	Dermal contact g/day (CON)
0 - 1	10	0.05	0.25	<b>`</b> 5	0
1 - 6	15	0.1	0.5	7.5	10
6 - 11	30	0.05	0.25	12	1
11 - 76.2	70	0.025	0.1	20	0.1
light industrial	70	0.025		8.25	0.1
heavy industrial	70		0.25	25.75	0.65

## HOME-GROWN VEGETABLE INTAKE (g/day)

	Leafy (VIL)	Root (VIR)	
0 - 1	0.50	0.53	
1 - 6	0.29	0.44	Rates are worst-case
6 - 11	0.51	0.77	Typical rates are half these values
11 - 76 2	1 44	1 04	• •

### **EQUATIONS**

EQ 1= SI\*SC\*ING\*CF/BW

EQ 2= [(VIL\*PL) + (VIR\*PR)]\*SC\*CF/BW

EQ 3= IR\*AC\*INH\*CF/BW

EQ 4= CON'SC'SF'DER'CF/BW

Ave lifetime dose=[Sum(dose\*time period)]/lifetime

EQ 5= PS\*Ave lifetime dose

EQ 6 = sum of risks

## CALCULATIONS FOR ONSITE RESIDENTIAL SCENARIO Worst-Case Exposure

Words Oude Expe	3010				
		Vegetable	Inhaled	Dermal	
	Soil Ingestion	Ingestion	Particulate	Absorption	
Age	Dose	Dose	Dose	Dose	
	mg/kg day	mg/kg day	mg/kg day	mg/kg day	
Years	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)	
0-1	3.52E-01	1.14E-02	4.02E-05	0.00E+00	
1-6	4.69E-01	4.78E-03	4.02E-05	0.00E+00	
6-11	1.17E-01	4.20E-03	3.22E-05	0.00E+00	
11 - 76.2	2.01E-02	4.39E-03	2.30E-05	0.00E+00	
Ave lifetime dose	6.03E-02	4.50E-03	2.49E-05	0.00E+00	-
risk (EQ 5)	1E-01	7E-03	1E-03	0E+00	
-			total risk (EQ 6)=	1E-01	risk (no

1E-01



### Typical Exposure

Age Years	Soil Ingestion Dose mg/kg day (EQ 1)	Vegetable Ingestion Dose mg/kg day (EQ 2)	Inhaled Particulate Dose mg/kg day (EQ 3)	Dermal Absorption Dose mg/kg day (EQ 4)		  
0-1	9.78E-03	7.91E-04	2.10E-05	0.00E+00		:
1-6	1.30E-02	3.32E-04	2.10E-05	0.00E+00	-	
6 - 11	3.26E-03	2.91E-04	1.18E-05	0.00E+00	-	-
11 - 76.2	6.98E-04	3.05E-04	8.40E-06	0.00E+00	-	
Ave Lifetime dose	1.79E-03	3.12E-04	9.61E-06	0.00E+00	•	
risk (EQ 5)	3E-03	5E-04	5E-04	0E+00		
•			total risk (EQ 7)=	4E-03	risk (no veg)=	3E-03

## **CALCULATIONS FOR ONSITE INDUSTRIAL SCENARIO**

## Heavy Industrial

Age Years	Soil Ingestion Dose mg/kg day (EQ 1)	Vegetable Ingestion Dose mg/kg day (EQ 2)	Inhaled Particulate Dose mg/kg day (EQ 3)	Absorption Dose mg/kg day (EQ 4)
20-60	3.62E-02	0.00E+00	2.10E-05	0.00E+00
Ave lifetime dose risk (EQ 5)	1.90E-02 3E-02	0.00E+00 0E+00	1.10E-05 6E-04 total risk (EQ 6)=	0.00E+00 0E+00 3E-02

## Light Industrial

Age Years	Soil Ingestion Dose mg/kg day (EQ 1)	Vegetable Ingestion Dose mg/kg day (EQ 2)	Inhaled Particulate Dose mg/kg day (EQ 3)	Dermal Absorption Dose mg/kg day (EQ 4)
20-60	5.03E-04	0.00E+00	3.51E-06	0.00E+00
Ave lifetime dose	2.64E-04	0.00E+00	1.84E-06	0.00E+00
risk (EQ 5)	4E-04	0E+00	9E-05	0E+00
•			total risk (EQ 6)=	5E-04



## **CALCULATIONS FOR OFFSITE RESIDENTIAL SCENARIO**

## Worst-Case Exposure

		Vegetable	Inhaled	Dermal
Age	Soil Ingestion	Ingestion	Particulate	Absorption
•	Dose	Dose	Dose	Dose
Years	mg/kg day	mg/kg day	mg/kg day	mg/kg day
	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
	(24.)	(===)	(220)	(24)
0 - 1	0.00E+00	0.00E+00	1.20E-05	0.00E+00
1-6	0.00E+00	0.00E+00	1.20E-05	0.00E+00
6-11	0.00E+00	0.00E+00	9.60E-06	0.00E+00
11 - 76.2	0.00E+00	0.00E+00	6.86E-06	0.00E+00
Ave lifetime dose	0.00E+00	0.00E+00	7.44E-06	0.00E+00
risk (EQ 5)	0E+00	0E+00	4E-04	0E+00
	•		total risk (EQ 6)=	4E-04

# CALCULATIONS FOR OFFSITE RESIDENTIAL SCENARIO Typical Exposure

		Vegetable	Inhaled	Dermal
Age	Soil Ingestion	Ingestion	Particulate	Absorption
	Dose	Dose	Dose	Dose
Years	mg/kg day	mg/kg day	mg/kg day	mg/kg day
	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
0 - 1	0.00E+00	0.00E+00	1.65E-06	0.00E+00
1 - 6	0.00E+00	0.00E+00	1.65E-06	0.00E+00
6 - 11	0.00E+00	0.00E+00	9.24E-07	0.00E+00
11 - 76.2	0.00E+00	0.00E+00	6.60E-07	0.00E+00
Ave lifetime dose	0.00E+00	0.00E+00	7.55E-07	0.00E+00
risk (EQ 5)	0E+00	0E+00	4E-05	0E+00
			total risk (EQ 6)=	4E-05



### **EXPOSURE ASSESSMENT FOR LEAD**

Assumptions and Parameters					
soil concentration-high rate	SCw	1.35E+01	mg/g	1.35E+04	ppm
soil concentration-mod rate	SCt	3.81E+00	mg/g	3.81E+03	ppm
ambient air on site (high)	AW	2.38E-04	mg/m3	2.38E-01	ug/m3
ambient air on site (typical)	AT	1.24E-04	mg/m3	1.24E-01	ug/m3
ambiet air off site high	WOA	7.10E-05	mg/m3	7.10E-02	ug/m3
ambiet air off site typical	TOA	9.76E-06	mg/m3		-
ingestion absorption resident	ING	4.20E-01	ratio		
dermal absorption	DER	0.00E+00	ratio		
inhalation absorption	INH	1.00E+00	ratio		
plant uptake leafy	PL	5.20E-03	g soil/g plant		
plant uptake root	PR	5.20F-03	a soil/a plant		

## AIC for LEAD:

oral (AICO) 1.40E-03 mg/kg-day inhal(AICI) 4.30E-04 mg/kg-day

## CORRECTION FACTORS FOR SCENARIOS (CF)

On-Site Residential			On-Site Industrial		Off-Site Residential	
Inhalation				,		
worst-case adult*	<b>CFRIAW</b>	1	CFIIA	0.71	CFOIAW	1
typical adult*	CFRIAT	0.7	CFIIC	0	CFOIAT	0.7
-child	CFRIC	1		-	CFOIC	1
Soil Ingest-adult	CFRSA	0.5	CFISA	0.36	CFOSA	0
child	CFRSC	0.5	CFISC	0	CFOSC	0
Veg Ingestadult	CFRVA	1	CFIVA	0.	CFOVA	0
-child	CFRVC	1	CFIVC	0	CFOVC	0
Dermal-adult	CFRDA	0.5	CFIDA	0.36	CFODA	0
-child	CFRDC	0.5	CFIDC	0	- CFODC	0

INTAKE RATES					Dermal
•	Body		Soil Ingestion	Inhalation	contact
Age	weight kg	(reasonable) g/day	(maximum) g/day	rate m3/day	rate g/day
	(BW)	(SIR)	(SIM)	(IR)	(CON)
0-1	10	0.05	0.25	5	0
1 - 6	15	0.1	0.5	7.5	10
6-11	30	0.05	0.25	12	1
11 - 76.2	70	0.025	0.1	20	0.1
light industrial	70	0.025		8.25	0.1
heavy industrial	70	•	0.25	25.75	0.65

## HOME- GROWN VEGETABLE INTAKE (g/day)

	Leafy (VIL)	Root (VIR)	
0 - 1	0.50	0.53	•
1-6	0.29	0.44	Rates are worst-case
6 - 11	0.51	0.77	Typical rates are half these values
11 - 76.2	1.44	1.04	

## **EQUATIONS**

EQ 1= SI\*SC\*ING\*CF/BW

EQ 2= [(VIL\*PL)+(VIR\*PR)]\*SC\*CF/BW

EQ 3= ÎR\*A\*INH\*CF/BW

EQ 4= CON'SC'DER'CF/BW

EQ 5= (Maximum oral dose of EQ 1 + EQ 2)/ AIC

## CALCULATIONS FOR ON-SITE RESIDENTIAL SCENARIO Worst-Case Exposure

Age	Soil Ingestion Dose	Vegetable Ingestion Dose	Inhaled Particulate Dose	Dermal Absorption Dose
Years	mg/kg day (EQ 1)	mg/kg day (EQ 2)	mg/kg day (EQ 3)	mg/kg day (EQ 4)
0 - 1	7.07E-02	7.22E-03	1.19E-04	0.00E+00
1-6	9.43E-02	3.41E-03	1.19E-04	0.00E+00
6 - 11	2.36E-02	2.99E-03	9.52E-05	0.00E+00
11 - 76.2	4.04E-03	2.48E-03	6.80E-05	0.00E+00
AIC (mg/kg-day) Hazard Index (EQ 5)	oral= oral=	1.40E-03 5.57E+01	inhal= inhal=	4.30E-04 2.77E-01

## Typical Exposure

		Vegetable -	Inhaled	Dermal	
Age	Soil Ingestion	Ingestion	Particulate	Absorption	
	Dose	Dose	Dose	Dose	
Years	mg/kg day	mg/kg day	mg/kg day	mg/kg day	
	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)	
0-1	4.00E-03	1.02E-03	4.34E-05	0.00E+00	
1-6	5.33E-03	4.82E-04	4.34E-05	0.00E+00	
6-11	1.33E-03	4.23E-04	3.47E-05	0.00E+00	
11 - 76.2	2.86E-04	3.51E-04	2.48E-05	0.00E+00	
AIC (mg/kg-day)	oral=	1.40E-03	inhal=	4.30E-04	
Hazard Index (EQ 5)	oral=	3.59E+00	inhal=	1.01E-01	

# CALCULATIONS FOR ON-SITE INDUSTRIAL SCENARIO Heavy Industry

Age Years	Soil Ingestion Dose mg/kg day (EQ 1)	Vegetable Ingestion Dose mg/kg day (EQ 2)	Inhaled Particulate Dose mg/kg day (EQ 3)	Dermal Absorption Dose mg/kg day (EQ 4)
20-60	7.28E-03	0.00E+00	6.22E-05	0.00E+00
AIC (mg/kg-day) Hazard Index (EQ 5)	oral= oral=	1.40E-03 5.20E+00	inhal= inhal=	4.30E-04 1.45E-01
Light Industry				
	<b>-</b>	Vegetable	Inhaled	Dermal
Age	Soil Ingestion Dose	Ingestion Dose	Particulate Dose	Absorption Dose
Years	mg/kg day (EQ 1)	mg/kg day (EQ 2)	mg/kg day (EQ 3)	mg/kg day (EQ 4)
20-60	2.06E-04	0.00E+00	1.04E-05	0.00E+00
AIC (mg/kg-day) Hazard Index (EQ 5)	oral=	1.40E-03 1.47E-01	inhal= inhal=	4.30E-04 2.41E-02

## CALCULATIONS FOR OFF-SITE RESIDENTIAL SCENARIO Worst-Case Exposure

Age Years	Soil Ingestion Dose mg/kg day	Vegetable Ingestion Dose mg/kg day	Inhaled Particulate Dose mg/kg day	Dermal Absorption Dose mg/kg day
	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
0 - 1	0.00E+00	0.00E+00	3.55E-05	0.00E+00
1 - 6	0.00E+00	0.00E+00	3.55E-05	0.00E+00
6-11	0.00E+00	0.00E+00	2.84E-05	0.00E+00
11 - 76.2	0.00E+00	0.00E+00	2.03E-05	0.00E+00
AiC (mg/kg-day)	orai=	1.40E-03	inhal=	4.30E-04
Hazard Index (EQ 5)	oral=	0.00E+00	inhal=	8.26E-02



••		Vegetable	Inhaled	Dermal
Age	Soil Ingestion	Ingestion	Particulate	Absorption
•	Dose	Dose	Dose	Dose
Years	mg/kg day	mg/kg day	mg/kg day	mg/kg day
	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
0 - 1	0.00E+00	0.00E+00	4.88E-06	0.00E+00
1 <b>- 6</b> °	0.00E+00	0.00E+00	4.88E-06	0.00E+00
6-11	0.00E+00	0.00E+00	2.73E-06	0.00E+00
11 - 76.2	0.00E+00	0.00E+00	1.95E-06	0.00E+00
AIC (mg/kg-day)	oral=	1.40E-03	inhal=	4.30E-04
Hazard Index (EQ 5)	oral=	0.00E+00	inhal=	1.13E-02





## **EXPOSURE ASSESSMENT FOR HEAVY PAHs**

A any model and	Dans == ataux					
Assumptions and soil concentration-soil concentration-dust in air high dust in air low ingestion absorption	-high rate -mod rate		SCW SCt ACW ACt ING	2.86E-01 4.16E-02 0.00E+00 0.00E+00 5.00E-01	mg/g mg/g g/m3 g/m3 ratio	2.86E+02 4.16E+01 above in ppm
dermal absorption inhalation absorpti half life degradation rate	l.		DER INH HL K	6.00E-02 1.00E+00 5.00E+00 1.39E-01	ratio ratio yrs 1/yrs	K=In2/HL
Datamari Diana fas	UE 410/ 04	! !=	·	•		
Potency Slope for	oral (PSO) inhal(PSI) der(PSD)	ns (as Benzo(a,	1.15E+01 6.11E+00 none	kg-day/mg kg-day/mg	-	
CORRECTION FA	ACTORS FO On-Site Residential	OR SCENARIOS	(CF) On-Site Industrial		Off-Site Residential	
Inhaladult child	CFRIA CFRIC	1	CFIIA CFIIC	0.71 0	CFOIA CFOIC	1 1
Soil Ingadult -child	CFRSA CFRSC	0.5 0.5	CFISA CFISC	0.36 0	CFOSA CFOSC	0
Dermaladult child	CFRDA CFRDC	0.5 0.5	CFIDA CFIDC	0.36 0	CFODA CFODC	0
INTAKE RATES	Body	Soil Ingest.	Soil Ingest.	Inhalation	Dermal contact	-
Age	weight kg (BW)	(reasonable) g/day (SI)	(maximum) g/day (SI)	rate m3/day (IR)	rate g/day (CON)	
0 - 1 1 - 6 6 - 11 11 - 76.2	10 15 30 70	0.05 0.1 0.05 0.025	0.25 0.5 0.25 0.1	5 7.5 12 20	0 10 1 0.1	
light Industrial heavy Industrial	70 70	0.025	0.25	8.25 25.75	0.1 0.65	



## EQUATIONS

EQ 1= (EXP(-K\*Beginning Age)-EXP(-K\*Ending Age))/K

EQ 2= SI\*SC\*CF/Body Weight EQ 3= IR\*AC\*SC\*INH\*CF/BW EQ 4= CON\*SC\*DER\*CF/BW
EQ 5= sum (dose\*decay factor )\*PS

EQ 6=sum of risks

## CALCULATIONS FOR ON-SITE RESIDENTIAL SCENARIO Worst-Case Exposure

				Inhaled	Dermal
Age		Decay	Soil Ingestion	Particulate	Absorption
_		Factor	Dose	Dose	Dose
years		years	mg/kg day	mg/kg day	mg/kg day
beg.	end	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
0	1	9.34E-01	1.78E-03	0.00E+00	0.00E+00
1	6	3.14E+00	2.38E-03	0.00E+00	5.71E-03
6	11	1.57E+00	5.95E-04	0.00E+00	2.86E-04
11_	76.2	1.56E+00	1.02E-04	0.00E+00	1.22E-05
Ave lifetime dose			1.34E-04	0.00E+00	2.41E-04
risk (EQ 5)	) =		1.5E-03	0.0E+00	
			total risk (	'EQ 6)=	1.5E-03

### Typical Exposure

Age		Decay Factor	Soil Ingestion Dose	Inhaled Particulate Dose	Dermal Absorption Dose
Years		Years	mg/kg day	mg/kg day	mg/kg day
beg.	end	(EQ 1)	(EQ 2)	(ÊQ 3)	(EQ 4)
0	1	9.34E-01	5.20E-05	0.00E+00	0.00E+00
1	6	3.14E+00	6.93E-05	0.00E+00	8.32E-04
6	11	1.57E+00	1.73E-05	0.00E+00	4.16E-05
11	76.2	1.56E+00	3.71E-06	0.00E+00	1.78E-06
Ave lifetime dose		3.92E-06	0.00E+00	3.51E-05	
risk (EQ 5)	-		4.5E-05	0.0E+00	
			total risk	(EQ 6)=	4.5E-05



## **CALCULATIONS FOR ON-SITE INDUSTRIAL SCENARIO**

Heavy I	Industry
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		-	Soil	inhaled	Dermal
Age		Decay	Ingestion	Particulate	Absorption
		Factor	Dose	Dose	Dose
Years		Years	mg/kg day	mg/kg day	mg/kg day
Beg.	end	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
20	60	4.45E-01	1.84E-04	0.00E+00	5.73E-05
Ave lifetime dose			1.07E-06	0.00E+00	3.34E-07
risk (EQ 5) =			1.2E-05	0.0E+00	•
			total risk	(EQ 6)=	1.2E-05

## CALCULATIONS FOR ON-SITE INDUSTRIAL SCENARIO Light Industry

Age Years Beg.	end	Decay Factor Years (EQ 1)	Soil Ingestion Dose mg/kg day (EQ 2)	Inhaled Particulate Dose mg/kg day (EQ 3)	Dermal Absorption Dose mg/kg day (EQ 4)
20_	60	4.45E-01	2.67E-06	0.00E+00	1.28E-06
Ave lifetime dose risk (EQ 5) =			1.56E-08		7.49E-09
			total risk	(EQ 6)=	1.8E-07

### **CALCULATIONS FOR OFF-SITE RESIDENTIAL SCENARIO**

## Worst-Case Exposure

	-		Soil	Inhaled	Dermal
Age		Decay	Ingestion	<b>Particulate</b>	<b>Absorption</b>
		Factor	Dose	Dose	Dose
Years		Years	mg/kg day	mg/kg day	mg/kg day
Beg.	End	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
0	1	9.34E-01	0.00E+00	0.00E+00	ро
1	6	3.14E+00	0.00E+00	0.00E+00	0.00E+00
6	11	1.57E+00	0.00E+00	0.00E+00	0.00E+00
11	76.2	1.56E+00	0.00E+00	0.00E+00	0.00E+00
Ave lifetime dose		0.00E+00	0.00E+00	#VALUEI	
risk (EQ 5)	=		0.0E+00	0.0E+00	
			total risk	(EQ 6)=	0.0E+00



## Typical Exposure

			Soil	Inhaled	Dermal
Age		Decay	Ingestion	Particulate	<b>Absorption</b>
•		Factor	Dose	Dose.	Dose
Years		Years	mg/kg day	mg/kg day	mg/kg day
Beg.	End	(EQ 1)	(EQ 2)	(EQ 3)	(EQ 4)
0	1	9.34E-01	0.00E+00	0.00E+00	0.00E+00
1	6	3.14E+00	0.00E+00	0.00E+00	0.00E+00
6	11	1.57E+00	0.00E+00	0.00E+00	0.00E+00
11	76.2	1.56E+00	0.00E+00	0.00E+00	0.00E+00
Ave lifetime dose			0.00E+00	0.00E+00	0.00E+00
risk (EQ 5)	<b>a</b>		0.0E+00	0.0E+00	
			total risk	(EQ 6)=	0.0E+00

APPENDIX C

CONCENTRATIONS OF METALS IN FUGITIVE DUST

#### APPENDIX C



#### CONCENTRATIONS OF METALS IN FUGITIVE DUST

This appendix supports the discussion of potential exposure for offsite residents via inhalation and deposition of fugitive dust from the site (see Section III.D. and Section V.A.). Metals in fugitive dust from the site were modeled by TRC Environmental Consultants. Two models were used to determine ambient air concentrations and deposition concentrations. The Fugitive Dust Model (FDM) was the preferred modeling technique due to its more realistic treatment of particle deposition. The FDM model also produced a more conservative estimate of both deposition and ambient air impact. The other model used was the Industrial Source Complex Model (ISC). This model was run at the request of the EPA and the results of this model are presented as a comparison.

The models were run for the arsenic. Concentrations were estimated for the other metals relative to the concentration of arsenic as determined from concentrations of metals measured in the surficial dust analysis (Parametrix et al., 1989).

Table C-1 presents the ambient concentrations of metals in airborne dust as maximum values averaged over eight-hours and one year. The annual concentrations were determined for both onsite and offsite, or residential, areas. The eight-hour maximum is used for evaluating air levels for workers, assuming industrial development of the site.

Onsite values used for the hypothetical residential and industrial site-use scenarios are given for the maximum annual average ("worst-case") and an intermediate isopleth within the boundaries of the site ("typical"). Figure 5 depicts how this isopleth was selected. Results from the FDM model were used conservatively for the risk assessment, some ISC model results are also given as a comparison.

Figure 5 also depicts the location of the maximum annual concentration off site in residential areas. The offsite areas considered residential by the risk assessment include non-Asarco property that is zoned for residential, recreational, or school use. This concentration is used for both the "worst-case" and "typical" conditions for the offsite residential exposure scenario.

Deposition of metals in fugitive dust is presented in Table C-2 as a maximum concentration over a one-year period. Offsite values are for highest impact ("worst-case") and for more realistic impacts in the area ("typical"). These approximate locations are depicted in Figure 6.

TABLE C-1

CONCENTRATIONS OF METALS IN AIRBORNE DUST



# FUGITIVE DUST MODEL (ug/m3)

Metal	On Site Annual maximum	On Site Annual typical	On Site 8-Hour maximum	Off Site Annual maximum	Off Site Annual typical
Antimony	4.21E-02	2.20E-02	7.22E-01	1.26E-02	1.73E-03
Arsenic	2.68E-01	1.40E-01	4.60E+00	8.00E-02	1.10E-02
Cadmium	2.23E-03	1.17E-03	3.83E-02	6.66E-04	9.16E-05
Copper	2.80E-01	1.46E-01	4.81E+00	8.36É-02	1.15E-02
Chromium	4.56E-03	2.38E-03	7.82E-02	1.36E-03	1.87E-04
Lead	2.38E-01	1.24E-01	4.08E+00	7.10E-02	9.76E-03
Mercury	1.44E-01	7.50E-02	2.47E+00	4.29E-02	5.90E-03
Nickel	6.70E-03	3.50E-03	1.15E-01	2.00E-03	2.75E-04

## INDUSTRIAL SOURCE COMPLEX MODEL (ug/m3)

Metal	On Site Annual maximum	On Site 8 Hour maximum	Off Site Annual maximum
Antimony	2.10E-02	1.70E-01	1.26E-02
Arsenic	1.34E-01	1.08E+00	8.00E-02
Cadmium	1.12E-03	9.00E-03	6.66E-04
Copper	1.40E-01	1.13E+00	8.36E-02
Chromium	2.28E-03	1.84E-02	1.36E-03
Lead	1.19E-01	9.58E-01	7.10E-02
Mercury	7.18E-02	5.79E-01	4.29E-02
Nickel	3.35E-03	2.70E-02	2.00E-03

See Figure 5 for on site and off site locations

TABLE C-2
DEPOSITION CONCENTRATIONS OF METALS

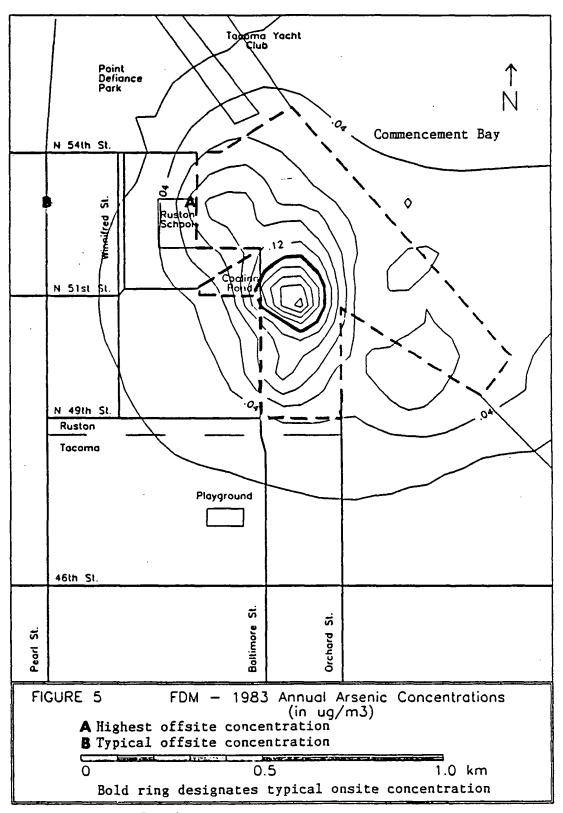
## FUGITIVE DUST MODEL (g/m2)

	On Site Annual maximum	Off Site Annual maximum	Off Site Annual typical
Antimony	1.90E-02	5.50E-03	4.24E-02
Arsenic	1.21E-01	3.50E-02	2.70E-01
Cadmium	1.01E-03	2.92E-04	2.25E-03
Copper	1.26E-01	3.66E-02	2.82E-01
Chromium	2.06E-03	5.95E-04	4.59E-03
Lead	1.07E-01	3.10E-02	2.39E-01
Mercury	6.49E-02	1.88E-02	1.45E-01
Nickel	3.03E-03	8.75E-04	6.75E-03

# INDUSTRIAL SOURCE COMPLEX MODEL (g/m2)

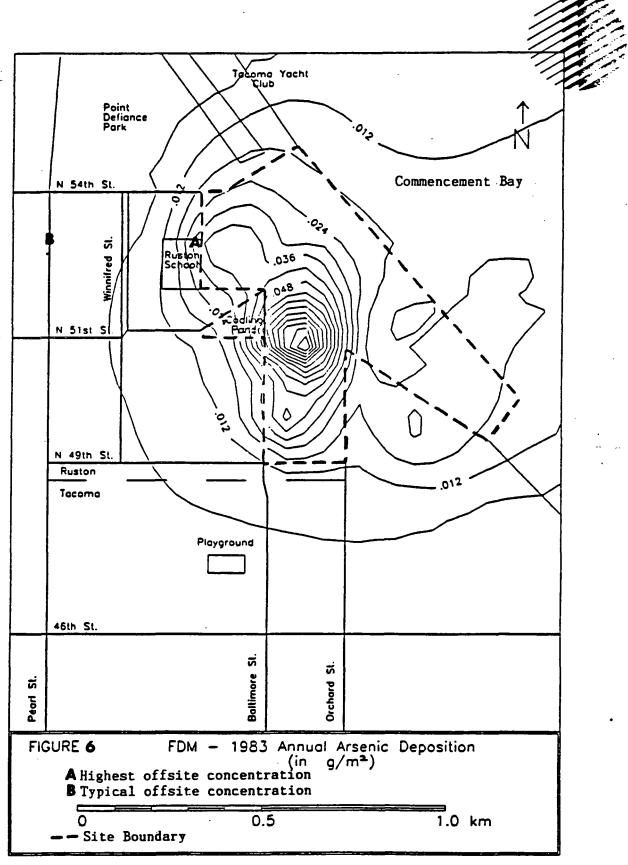
	On Site Annual	Off Site Annual
	maximum	maximum
Antimony	1.21E-04	8.16E-05
Arsenic	7.70E-04	5.20E-04
Cadmium	6.41E-06	4.33E-06
Copper	8.05E-04	5.43E-04
Chromium	1.31E-05	8.84E-06
Lead	6.83E-04	4.61E-04
Mercury	4.13E-04	2.79E-04
Nickel	1.93E-05	1.30E-05

See Figure 6 for on site and off site locations



-- Site Boundary

Parametrix et al. (1989)



Parametrix et al. (1989)

# APPENIDEX D

ADDITIONAL TOXICOLOGICAL INFORMATION FOR SELECTED CHEMICALS OF CONCERN



#### APPENDIX D

# ADDITIONAL TOXICOLOGICAL INFORMATION FOR SELECTED CHEMICALS OF CONCERN

#### ANTIMONY

Antimony at the site is assumed to be present as either metallic dust or a mixture of soluble salts. Antimony poisoning can affect the lungs, mucous membranes, skin, circulatory system, and gastrointestinal tract, depending on the dose and the duration of exposure. The symptoms of chronic exposure to low levels in humans were observed in studies of occupational exposure. Antimony smelter workers have commonly developed pneumoconiosis, which may be benign (Stokinger, 1982; Elinder and Friberg, 1986). Transient pustular skin eruptions, known as "antimony spots", are frequently observed in workers occupationally exposed to high levels of antimony and antimony salts (Elinder and Friberg, 1986).

#### ARSENIC

#### 1. Uptake and Metabolism

The toxicity of arsenic varies with its chemical form. The primary valences of concern in this risk assessment are trivalent and pentavalent inorganic arsenic. Trivalent (arsenite) compounds are more acutely toxic than pentavalent (arsenate) compounds, but at levels found in the environment arsenite is rapidly converted to arsenate (USEPA, 1987b).

Inorganic arsenic can be methylated in the environment and in the human liver. Methylation is generally viewed as a detoxification mechanism which hastens elimination of arsenic via the urinary tract (USEPA, 1987b). Arsenic methylation is inhibited in people with protein- or choline-deficient diets. These people are, therefore, a potential sensitive population for arsenic toxicity.

Absorption of ingested arsenic varies markedly with the water solubility of the compound (USEPA, 1984a). Soluble inorganic compounds, such as arsenic trioxide, are almost completely absorbed, while an insoluble compound, such as arsenic trioxide, has negligible absorption. The physical form in which these compounds are administered may also affect absorption since a suspension of arsenic trioxide was absorbed to a much more



limited degree than a solution (i.e., 30 to 40 percent for the suspension compared to up to 95 percent for the solution).

For inhaled arsenic, limited studies suggest deposition of 40 percent of most forms with a net absorption of at least 30 percent of the amount inhaled (USEPA, 1984a). Dermal absorption appears to be negligible (USEPA, 1988e).

In man, there does not appear to be long-term accumulation of arsenic in physiologically active compartments of the body (USEPA, 1984a). Arsenite reacts with sulfhydryl groups of proteins (Goyer, 1986). Binding by this mechanism explains the relatively high levels of arsenic found in hair, skin and stomach. Arsenate may interfere with phosphorylation reactions due to its chemical similarity to phosphate. This similarity may explain its relatively high levels in the skeleton (USEPA, 1988e).

Approximately 50 to 80 percent of absorbed arsenic is thought to be eliminated via the urinary tract (USEPA, 1988e; Goyer, 1986). This has led to the use of urinary arsenic levels as an indicator for exposure. Secondary routes of elimination include feces, hair, sweat and desquamation of skin (Goyer, 1986).

#### 2. Non-carcinogenic Effects

Levels of arsenic in some areas of the site may be high enough to result in adverse non-carcinogenic effects. At the extreme, the "worst-case" dose for infants is half (352 ug/kg/d) of the lowest observable adverse effect level (LOAEL) reported for lethality in infants (ATSDR, 1987a). The "worst-case" dose for adults is equal to the LOAEL for skin and cardiovascular effects (20 ug/kg/day). The "typical" dose for infants hypothetically on site is equal to the no observable adverse effect level (NOAEL) for arsenic (10 ug/kg/d), whereas "typical" dose for adults (0.7 ug/kg/day) is below the NOAEL (ATSDR, 1987a).

Other effects associated with chronic exposure include injury to the peripheral and central nervous systems (USEPA, 1984a). Effects on the central nervous system are less well characterized than effects on the peripheral nervous system, which begin with sensory changes (numbness, tingling, "pins and needles" sensation, and decreases in touch, pain and temperature sensations). Subsequently, motor nerves become affected as well.

A cardiovascular effect, called blackfoot disease, is prominent in Taiwanese populations exposed to arsenic via well water. This is a peripheral vascular disease leading to gangrene of the extremities (USEPA, 1984a). Due to the presence of other chemicals in the well



water, and to conflicting data from other studies, a general relationship between arsenic and cardiovascular disease has not been developed.

#### 3. Carcinogenic Effects

Risk assessments for arsenic are generally based on the induction of lung cancer by inhaled arsenic and the induction of skin cancers by ingested arsenic. These are the effects of greatest concern for chronic exposure to relatively low levels.

The EPA inhalation potency factor of 50 (mg/kg/day)-1 was developed from studies of human males occupationally exposed to arsenic via inhalation (USEPA, 1988a).

The ingestion potency factor has recently been revised by CAG (USEPA, 1988e). The new estimate, 1.65 (mg/kg/day)-1, is almost an order of magnitude lower than the estimate issued in 1984, which was 15 (mg/kg/day)-1. The difference is due to a revised evaluation of the same study upon which the original cancer potency was based. In the later study, incidence of skin cancer in people exposed to arsenic in drinking water in Taiwan was analyzed using the generalized multistage model. The differences between the two evaluations are summarized below:

- o For the new estimate, a model which was both linear and quadratic for dose was found to fit the data significantly better than the linear model used for the 1984 estimate.
- o The new estimate uses a life-table approach based on age-specific U.S. mortality data to calculate lifetime risk, whereas the previous estimate assumed an individual lived to be 76.2 years old.
- The new study uses a maximum likelihood estimate of prevalence rates (which takes into account the relatively small populations in older age groups), whereas the previous estimate used a least squares linear regression.
- The new estimate assumes Taiwanese males drink 75% more water than the U.S. population because they perform heavy work outdoors in a hot climate, whereas the previous estimate assumed comparable water intake.
- The new estimate includes data on Taiwanese females which was excluded from the previous estimate.

A number of unresolved issues make it likely that the new potency factor will be revised again in the future as new data become available. These include:

- o The low fatality rates associated with arsenic-induced skin cancers compared to other cancers and the ability to successfully treat these cancers may lead to a further reduction of the estimate.
- o Preliminary evidence that the actual dose-response curve may not be linear could also lead to a further reduction of the estimate.
- o Evidence that arsenic may be an essential element could lead to the establishment of a threshold for adverse effects.

There are also some problems associated with the Taiwanese study which might lead to new estimates in the future if a better study becomes available. The problems include:

- o The Taiwanese population studied also had a high incidence of blackfoot disease associated with arsenic exposure. The earlier onset and higher case-fatality rate from this disease may have led to an underestimate of cancer cases.
- o The presence of other chemicals (ergotamine) in the water supply may have influenced the cancer incidence.
- The investigators determining the cancer incidence were familiar with the subjects' arsenic exposure and may, therefore, have introduced bias into the study.
- The study did not take into account exposure to arsenic via diet, a factor which may have lead to a maximum 30 percent overestimate of risk.

#### LEAD

The major routes of inorganic lead absorption are the gastrointestinal tract and the respiratory system. The rate of absorption of lead from the gastrointestinal tract can be markedly influenced by the level of calcium, iron, fats, and proteins in the diet, and is higher in infants than in adults.



After long-term exposure, approximately 90% of the total body burden of lead is sequestered in the bones. Some lead is also stored in the liver and kidneys. In these organs, lead appears in dense intranuclear inclusion bodies. Excretion occurs via bile and urine, and by exfoliation of epithelial tissue. Over time, the fractional excretion of the lead body burden becomes progressively smaller (Goyer, 1986).

Lead poisoning affects the central nervous system, peripheral nerves, kidneys and red blood cells. At low levels of exposure, neurological and hematologic effects in children are of greatest concern. A blood lead level of 30 ug of lead/dl of blood was previously accepted as the "maximum safe level" for pediatric exposures; however, the threshold for observed adverse effects continues to decline as additional studies are conducted. For example, a highly significant association has been found between IQ and blood lead levels over a range of 6 to 47 ug/dl (USEPA, 1988b). As a result, the EPA now considers 10-15 ug/dl (and higher) as the appropriate range of concern for adverse health effects (USEPA, 1988b).

Differences in environmental lead levels are reflected in the blood levels of children from urban and rural areas. Studies have demonstrated that for every 1000 ppm increase in soil lead levels, the blood lead in children will increase 0.6 to 6.8 micrograms of lead perdeciliter of blood (ug/dl). A reasonable mean estimate is 2.0 ug/dl (USEPA 1986a). For 2-to 3-year-old children, who generally have the highest blood lead levels, geometric mean blood levels from 1976 to 1980 were 19.3 to 20.9 ug/dl in urban areas and 16.4 ug/dl in rural areas.

The EPA has recently reviewed the available data on the carcinogenicity of lead and has classified lead as a probable human carcinogen based on evidence in animals (USEPA, 1988b). In carcinogenic studies in rodents, exposure to relatively high doses of lead resulted in primarily renal tumors (USEPA, 1986a). Little can be concluded at this time about the carcinogenicity of lead in humans from the available epidemiological data (USEPA, 1986a). These human studies generally lack controls for other contributing factors to carcinogenicity.

A carcinogenic potency slope has not been determined for lead because of difficulty in evaluating the dose-response data in animals. Although the results from animal tests clearly indicated that lead is a carcinogen, the levels required to induce tumors are considerably higher than the no effect level for non-carcinogenic effects. Accordingly, the EPA has concluded that lead does not appear to be a potent carcinogen and that the non-carcinogenic effects of lead are of greatest concern at low levels for regulatory purposes (USEPA, 1988b).



#### **HPAHs**

Although HPAHs were selected as indicator chemicals, these compounds are usually present in petroleum hydrocarbon mixtures. This section provides additional toxicological information on other components of these PAH-containing mixtures. HPAHs are one of the many components of petroleum hydrocarbon mixtures which also include alkanes, alkenes. cycloalkanes, and other aromatic hydrocarbons in varying proportions with nitrogen, sulfur, and oxygen-containing compounds in much smaller amounts (USEPA, 1981b; The chronic toxicity of most of the alkanes, alkenes, and Sandmeyer, 1981a,b). cycloalkanes in petroleum products are quite low (Sandmeyer, 1981a,b). An exception is nhexane and closely related n-alkanes which cause degeneration of peripheral nerves. The neurotoxic action of n-hexane has generally been limited to workers exposed to high levels in an occupational setting. Several of the higher n-alkanes, such as dodecane, have been shown to act as cocarcinogens, enhancing the tumorigenic response of mice to dermal treatment with some polycyclic aromatic hydrocarbons such as benzo[a]pyrene. Larger alkanes and alkenes (those with 20 carbon atoms and greater) which are solids at room temperature are considered practically non-toxic.

Due to the extreme variations in composition of petroleum products, the hazard of a particular product would depend on the precise chemical composition (e.g., benzene, and PAH composition) and on the process used to refine the product from crude oil. Predictions of carcinogenic activity could be further complicated by the presence of cocarcinogens. Additives and contaminants such as heavy metals could pose additional hazards, although conversely, other components such as polycycloparaffins may reduce the bioavailability of PAHs in petroleum mixtures (Lewis et al., 1984).

The greatest hazards of petroleum products are those associated with the aromatic hydrocarbons in these products. At the site, the polycyclic aromatic hydrocarbons pose the greatest hazards. Carcinogenic PAHs have been shown to cause skin tumors in laboratory animals when applied to skin repeatedly. Benzo(a)pyrene is considered the most potent. At least 14 PAHs have been shown to be carcinogenic and several additional compounds are reported to be mutagenic, but have not yet been adequately tested for carcinogenicity (IARC, 1983). This risk assessment followed EPA guidelines which suggest that all PAHs should be considered as potent as benzo(a)pyrene.

It should be noted that there are also a number of PAHs that do not demonstrate carcinogenic or mutagenic activity. These compounds generally are the lower molecular weight PAHs.



#### **CADMIUM**

The nature of the effects of chronic cadmium poisoning vary according to the route of intake. Chronic inhalation of cadmium can result in the development of lung cancer. Emphysemous and fibrotic changes in the lungs have been documented in animals and humans following chronic exposure. All of these changes, which may persist after removal from exposure, can be attributed to local irritation of the respiratory tract (Goyer, 1986).

The kidney is also a major target organ of chronic cadmium toxicity. Renal tubular disease with proteinuria has been observed following long-term ingestion and inhalation exposure. Long-term ingestion of cadmium has also been associated with anemia and liver disturbances. Cadmium accumulates in all tissues; however, the kidney accumulates the most (up to 50% of the total body burden (Friberg et al., 1986). The selective concentration of cadmium in the kidney may account for the toxic effects characteristically found in that organ.

#### **CHROMIUM**

Hexavalent chromium is more easily absorbed from the lungs and gastrointestinal tract than is trivalent chromium. This fact probably accounts for the greater toxicity of hexavalent chromium than trivalent chromium. Chromium accumulates selectively in the lung as a result of deposition over time (Langard and Norseth, 1986). Once absorbed and bound in tissue macromolecules, chromium compounds are found in trivalent form. The hexavalent chromium compounds are strong oxidizing agents and are easily reduced. In vivo reduction of the readily absorbed (more soluble) hexavalent form to the trivalent form may be of importance for the toxicity of chromium compounds. Unlike most other toxic metals, chromium levels in tissues other than the lung decrease with age.

Inhalation exposure to high levels of hexavalent chromium can result in bronchiogenic cancer. The specific hexavalent chromium compounds with maximum carcinogenic activity have yet to be identified (Langard and Norseth, 1986). The most common toxic effects of exposure to hexavalent chromium are dermatitis, ulcerations of the mucous membranes, and allergic asthmatic reactions.



#### COPPER

There are no quantitative data on the effects of respiratory uptake of copper in humans or animals. In humans, some short-term toxic effects (influenza-like symptoms) have been observed following industrial exposure to copper dust or fumes. Gastrointestinal absorption is regulated by the copper level in the body, and varies with the form of the copper compound ingested (Aaseth and Norseth, 1986). Ingestion of small amounts of copper salts induces vomiting.

Two distinct copper-sensitive populations have been identified. Glucose-6-phosphodehydrogenase (G6PD) deficient individuals may be at risk from exposure to copper, as excess copper reduces the activity of the hexose monophosphate shunt in which G6PD is involved (USEPA, 1984d). The incidence of G6PD deficiency is estimated to be 13% of the American black male population (USEPA, 1984d). Also at risk are those with the inherited disorder of copper metabolism known as Wilson's disease, or hepatolenticular degeneration. The prevalence of patients diagnosed with Wilson's disease is 1 in 30,000 (Sternlieb and Scheinberg, 1985).

#### MERCURY

Biotransformation and tissue distribution of mercury in humans are influenced by valence state and anionic component as well as by route of exposure. Organic mercury is efficiently absorbed by ingestion and readily crossess the blood-brain barrier. It may cause brain damage and teratogenic effects (Berlin, 1986; Goyer, 1986). Eighty percent of metallic mercury vapor is absorbed and retained by the lungs, whereas less than 0.01% is absorbed via ingestion (Goyer, 1986). This form also affects the brain and central nervous system due to accumulation in this organ (USEPA, 1984e). Inorganic mercury salts are more likely to be associated with gastrointestinal disturbance and kidney effects (Berlin, 1986; Goyer, 1986).

# APPENDIX E

UNCERTAINTY IN RISK ASSESSMENT



#### APPENDIX E

#### UNCERTAINTY IN RISK ASSESSMENT

#### A. OVERVIEW

This appendix begins with a general overview of uncertainty in risk assessment, then presents the sources of uncertainty and the effects of the assumptions in this risk assessment on the results.

Although there are many sources of uncertainty in a health risk assessment, this should not imply that the results are not useful. Rather, it is important to identify the sources and effects of uncertainty in order to provide defensible health risk estimates, highlight the uncertainty in the conclusions, and minimize subjective interpretation of the nature and degree of risk posed by site contaminants. Most assumptions are intentionally conservative so that the risk assessment will be more likely to overestimate risk than to underestimate it. However, in some cases the nature of the uncertainty is such that the impact of the assumptions made on the risk assessment cannot be determined. When insufficient data necessitate the use of subjective estimates of input variables, risks may be underestimated. Uncertainty factors are used to compensate for lack of data to ensure that risks aren't underestimated.

#### 1. Data Limitations

A health risk assessment examines the source of a contaminant, its dispersion and resulting exposure to humans, and the toxicological effects of that exposure. There are many chemicals for which there is little information about degradation, partitioning between soil, water and air, reactions in the environment, the uptake rates in plants and animals (which can result in indirect exposure to humans), the absorption rates in humans from various routes of exposure, or the toxic effects of chronic, low-dose exposure.

#### 2. Propagation of Error

A major problem with the quantitative aspect of risk assessments is the propagation of error. Calculation of risk is a sequential process, with the estimates from one section used as the assumptions in the next. As a result, the errors are compounded at each step (e.g., the uncertainties and errors in the sampling data are compounded by uncertainties and errors in the exposure and risk calculations).



In order to minimize the error propagation in this assessment, most of the environmental partitioning and exposure calculations used are linear, so that no parameter has a stronger or weaker effect on the result than any other parameter (e.g., doubling either the intake rate or the ambient concentration doubles the risk for a given route of exposure).

A type of sensitivity analysis was performed by calculating a range of "typical" and "worst-case" risks to cover the variety of possible exposure scenarios. "Typical" exposure incorporated more realistic intake rates and mean soil concentrations. Worst-case calculations used highly conservative assumptions and the upper 95 percentile soil concentration. The range in onsite risks between worst-case and "typical" calculations was approximately an order of magnitude in most cases, which represents the variation in outcomes of risk calculations. Even though risk estimates for carcinogens are presented as a number followed by the order of magnitude (e.g.,  $2x10^{-6}$ ), the accuracy of the models used is such that only the order of magnitude (e.g.,  $10^{-6}$ ) is considered reliable.

#### 3. Qualitative Analysis of Uncertainty

The amount of uncertainty in risk assessment cannot be easily quantified. In order to accomplish a standard statistical analysis of uncertainty, it is necessary to have a quantitative estimate of the range of each variable and each source of error, as well as information on the underlying statistical distribution of each parameter. In many cases, so few measurements are available or so little is understood about the physical processes involved, that any estimates of bounds on the risk would be nearly meaningless. In such cases, it is more useful to perform a qualitative uncertainty analysis.

In almost every case when the relative effect on risk could be determined, the value of a parameter (such as an inhalation rate or a home-grown vegetable intake rate) was chosen to overestimate risk. The effect of some parameters on risk depends on the calculation used, or on the value assigned to another parameter in the calculation. For some factors, the qualitative effect can be determined by considering what the results would be if more data were available. There remain some assumptions, however, for which the qualitative effect cannot be known without additional data or further advances in scientific theory.



#### C. SOURCES AND EFFECTS OF UNCERTAINTY

Assumptions must be made when values are unknown or when a multitude of values are possible. The qualitative effects of the major assumptions made for this risk assessment are discussed below.

#### 1. Factors Leading to Overestimation of Risk

#### a. Site Characterization

The risk assessment of exposure to chemicals in soil is based on the results of sampling which concentrated on specific areas on the property. These sites were judged to be most highly contaminated on the basis of detailed records of site activities. Thus, exposure concentrations tend to overestimate the actual exposure by hypothetical site residents.

#### b. Hazard Identification

- o No physical or chemical contaminant loss (except for degradation of HPAHs) was assumed for contaminants in the soil. In other words, each individual is assumed to be exposed to the original level of contamination for a lifetime. The use in this assessment of the upper 95 percentile level of site sampling results to calculate "worst-case" exposure greatly overestimates the amount of each chemical present at the site.
- o Because the exact form of the metals was not empirically determined, we assumed that the metals were in the most toxic form possible at the site. For example, nickel was assumed to be nickel subsulfide; chromium was assumed to be hexavalent. Mercury was assessed as its most toxic form by each route.

#### c. Exposure

O Under the residential site use scenario, the individual receiving "worst-case" exposure is considered to reside continuously at the location of the highest measured soil concentrations and the highest concentrations in air for a lifetime, breathing outdoor air all day, and eating home-grown vegetables. This will overestimate risk, since only a fraction of these exposures would actually occur.



- Results of the FDM model were used to approximate ambient levels and offsite deposition of fugitive dust. This model gives more conservative results than the EPA-approved ISCLT model. The concentration assumed for "typical" exposure was an intermediate isopleth within the site boundaries. This isopleth is considerably higher than a true average exposure for the site based on equal probability of living in a given location.
- The particulate matter leaving the site was assumed to have the same density as arsenic trioxide which is denser than most other forms of metals present. Because larger particles will deposit closer to the source, the estimates near the property line will be overestimated (Parametrix et al., 1989).
- o Hypothetical site uses and offsite exposure assume that the present soil conditions remain for a lifetime of exposure. In reality, landscaping and paving would reduce the exposure to bare soil and to dust.
- Residents of all ages were assumed to ingest soil everyday for six months of the year. This may be unrealistic for infants who are too young to crawl and therefore would not ingest much house dust or soil. EPA guidelines do not always include soil ingestion as a significant pathway of exposure for adults (USEPA, 1986c). Nevertheless, the inclusion of this pathway may make up for other routes which were not assessed for all chemicals such as home-grown vegetable ingestion of other chemicals besides metals.
- o Because of the limited quantitative data on how actual human absorption rates differ from the absorption rates assumed in computing EPA potency factors and AlCs, we frequently made conservative assumptions in calculating absorption for different routes of exposure. For example, 100% absorption was assumed for most chemicals. In reality, metals ingested in soil may be less bioavailable versus dissolved metals in solution fed to laboratory animals.

#### d. Toxicity Assessment and Risk Calculations

For carcinogens, the conservative assumption is made that some finite risk is associated with exposure to even one molecule of a compound. The approved potency slopes and acceptable daily intakes for chronic exposure are generally based on linear high-to-low-dose extrapolations. Because EPA potency slopes are based on upper 95% confidence limits and not on fitted model values, carcinogenic risks may be overestimated (Sielken, 1987). In addition, detoxification reactions in



the body may significantly reduce the risk of cancer at low doses (Williams and Weisburger, 1986). Some chemicals such as PCBs are have been found to be tumor promoters rather than tumor initiators at low doses.

- o The EPA methodology also uses interspecies extrapolation to develop toxicity criteria. If carcinogenic effects have been shown in any species, the compound is classified as a possible or probable human carcinogen. In reality, some compounds that have been found to be animal carcinogens such as PCBs do not appear to cause similar effects in humans (USEPA, 1986b).
- o The EPA criteria used for the toxicity assessment and risk characterization steps are inherently conservative. Because of the numerous data gaps involved at all levels, conservative assumptions are multiplied at the various stages of these calculations.
- o Because of lack of toxicity data on HPAH compounds, all of these compounds were evaluated as 100% benzo[a]pyrene, which is considered the potent of the carcinogenic PAHs.
- The cancer potency factors and risk estimates do not account for differences in treatability of cancers caused by different chemicals. For example, skin cancer, which can be induced by arsenic, is considered to be much more treatable than other forms of cancer (USEPA, 1984a). Assuming that treatability is the same for all cancers does not affect the estimation of cancer risk, but it does affect predictions of the survival rate associated with cancers caused by different chemicals.
- The health risks of exposure via inhalation of mercury in fugitive dust were conservatively assessed using the EPA criterion for mercury vapor, which is absorbed and retained by the lungs to a greater extent than other forms of mercury which are more likely to be present in dust. Absorption of mercury vapor is reported to be 80%, whereas absorption of other forms is estimated to be far less but has not been quantified (Berlin, 1986; ATSDR, 1989). Thus, risk estimates for mercury inhalation are likely to be overestimated.

#### 2. Factors Leading to an Underestimation of Risk

#### a. Sile Characterization

o A risk assessment depends heavily on the quality and representativeness of sampling data. Because principally one company and the same industry have used



the site for most of its industrial history, the historical records of the property are likely to be more accurate than those from most industrial sites. Nevertheless, there is still a possibility that unsampled areas may contain some contamination as well. The statistical calculations of an upper 95% level, however, will reduce some of the uncertainty in the sampling data.

o Surface soil samples are from the upper foot. The possibility therefore exists that concentrations may be higher at depth because of filling of the site. Residents, however, are more likely to be exposed to surface layers.

#### b. Exposure

- o Inhalation of the organic indicator chemicals was not included in this risk assessment. The risks from this route of exposure were determined qualitatively to be minor compared to the oral and dermal pathways.
- o Inhalation of metallic mercury vapor could not be assessed because of the lack of site data and uncertainty in the amount present. On the other hand, mercury in dust was conservatively assessed as mercury vapor, the more toxic form.
- Vegetable uptake rates of chemicals could not be adequately determined for all chemicals, therefore risks from all indicator chemicals due to vegetable consumption could not be calculated. Vegetable uptake was quantified, however, for the chemicals that are the major determinants of site risk.
- Skin penetration by mercury has been demonstrated for direct application of some forms of mercury; however, the available data are insufficient to quantify the amount that would be absorbed from soil. In some studies involving metallic mercury, it was uncertain whether the increase in blood levels of mercury were due to skin absorption or to inhalation (USEPA, 1984g). Absorption of mercuric chloride applied directly to the skin of laboratory animals is reported to be 8% (Berlin, 1986). In reality, dermal absorption of mercury from soil is likely to be far less than for direct application of mercury to skin, because mercury complexes and strongly binds to soil particulates, thereby greatly reducing its mobility (USEPA, 1984e).

#### c. Toxicity Assessment and Risk Characterization

The local effects of dermal exposure to chemicals could not be evaluated because of the lack of an established EPA method and quantitative criteria to evaluate dermal



exposure. This underestimates the risk to chemicals such HPAHs which have been shown to cause skin tumors via chronic dermal exposure in skin painting tests of rodents (IARC, 1983). Individual PAH compounds have not be shown to be carcinogenic in humans; however, long-term exposure to PAH mixtures in workers has been shown to result in skin cancer (USEPA, 1984f).

o Criteria were not available for all chemicals. Thus, the risks due to m-nitroaniline and unchlorinated dibenzofuran and dibenzothiophene could not be quantitatively assessed. In the low concentrations present, however, these chemicals are not likely to be a health concern relative to the other indicator chemicals. The current literature indicates that these chemicals are not carcinogenic and therefore would not add to the overall carcinogenic risk for the site.

#### 3. Factors With Unknown Contribution to Uncertainty

#### a. Hazard Identification

- o Reactions in the environment could result in new compounds with either more or less toxicity than the precursors.
- o Because the future use of the property is unknown, different scenarios were selected to assess risks for possible uses. All of the assumptions made concerning the routes and duration of exposure will contribute to the uncertainty of the assessment. To qualify this uncertainty, both "typical" and "worst-case" risks are presented to cover a variety of possible exposure scenarios.
- o It is assumed that the most toxic chemicals and those present in the greatest quantities have been identified as indicator chemicals, but in the absence of exhaustive soil sampling efforts it is impossible to determine whether or not this is the case.

#### b. Exposure

- o The modeling uncertainties in the exposure calculations will result in assumed exposure point concentrations which are too high at some locations, and too low at others.
- Assumptions are made about behavior, such as outdoor play and gardening, which may not accurately account for actual exposures.



#### c. Toxicity Assessment and Risk Characterization

- o In screening for indicator chemicals, several chemicals, such as phthalate esters, currently lack EPA-approved criteria that quantitatively describe their toxicity. In order to characterize the toxicity of these chemicals, we used alternative approaches which contribute additional uncertainty.
- o Indicator chemicals may have synergistic or antagonistic interactions which could increase or decrease their toxicity. For example, some metals such as zinc and selenium decrease the uptake and toxicity of other chemicals like cadmium (Goyer, 1986).
- When the responses from high-dose animal toxicity studies are extrapolated to low doses in humans, an uncertainty factor of 100 or greater is applied to the no-observed adverse-effect-level (NOAEL) to determine an acceptable (or "safe") dose for humans. The more uncertain the data, the greater the uncertainty factor. Although these EPA guideline are likely to overestimate of the risk in most cases, the relationship to the actual risk is unknown because of limitations in the available data.

#### D. SUMMARY

Every aspect of risk assessment contains significant sources of uncertainty. In each step assumptions are made so that the total risk can be estimated quantitatively. The exact degree of uncertainty cannot be quantified. In terms of protecting public health, however, preventing underestimation of the risk is far more important than calculating the exact risk for a given population. For this reason, "worst-case" risks are predicted which are unlikely to underestimate the risk to the most exposed individuals, and "typical" risks are calculated as a more realistic (but still conservative) comparison of site risks. It is therefore understood that following EPA risk assessment methods will likely overestimate the actual risk to public health and the environment.

# Final Report

# ASARCO Tacoma Smelter Remedial Investigation

Volume 5 — Description of the Current Situation.

# March 1989

# Parametrix, Inc.

in Association with Hart Crowser and TRC

#### DESCRIPTION OF CURRENT SITUATION

FOR

# THR ASARCO TACOMA SMELTER REMEDIAL INVESTIGATION

Prepared for ASARCO, INC.

Prepared by

PARAMETRIX, INC.
HART CROWSER, INC.
TRC ENVIRONMENTAL CONSULTANTS, INC.

PMX #55-1643-03 August 24, 1987

# TABLE OF CONTENTS

	<u> </u>	age
1.0	INTRODUCTION	1
2.0	SITE DESCRIPTION	2
	2.1 Facility Ownership and Description	
	2.2 Hydrogeology	
	2.2.1 Regional Hydrogeology	
	2.2.1.1 Stratigraphy	
	2.2.1.2 Water Supply	
	2.2.1.3 Groundwater Flow, Recharge and Discharge	
	2.2.1.4 Groundwater Quality	
	2.2.2 Project Site Hydrogeology	
	2.2.2.1 Topography	24
	2.2.2.2 Stratigraphy	24
	2.2.2.3 Subsurface Soil Quality	
	2.2.2.4 Groundwater Units	
	2.2.2.5 Groundwater Flow	32
	2.2.2.6 Water Rights	34
	, 2.2.2.7 Groundwater Quality	
3.0	SITE HISTORY	26
3.0	3.1 History of the Site	
	3.2 History of Significant Events and Legal Actions	70
	5.2 distory of Significant Events and Legal Actions	40
4.0	NATURE AND EXTENT OF THE PROBLEM	49
	4.1 Migration Pathways	
	4.1.1 Subsurface	
	4.1.2 Surface Water	
	4.1.3 Atmospheric	
	4.1.4 Aquatic and Biological Resources	
	4.2 Receptors	
	4.3 Potential Impacts	
	4.3.1 Groundwater	
	4.3.2 Surface Water	
	4.3.3 Air Quality	
	4.3.4 Aquatic and Biologic Resources	
	•	
5.0	SITE BOUNDARY	60
	THERE AT ADMIDT AT MAKE AND A CHARGE	.,
6.0	INITIAL REMEDIAL MEASURES	91
7.0	POTENTIAL GENERAL RESPONSE ACTIONS	67
3.0	DATA NEEDS	69
	8.1 Waste Characterization	
	8.2 Groundwater	
	8.3 Surface Water	
	8.4 Soils	

8.5	Air Quality	•	•	•	•	•	•	•	•	•	•	•	•	٠	•	•	.71
8.6	Aquatic and Biological Resources		•	•	•	•	•	•	•	•	•	•	•	•	٠	•	.72
8.7	Receptor Identification		•	•		•	•	•	•	•	•	•	•	•	٠	•	.73
8.8	Slag Leaching and Radon Emissions	3.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	.73
REFERENCES	S			•						•	•	•	•	•	•	•	.75

### LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1	Vicinity Map
2	Facility Map
3	Process Flow Diagram 6
4	Groundwater Regions
5	Regional Geologic Map
6	Regional Geologic Cross Section A-A' and B-B'14
7	Summary of Regional and Project Site Geologic Units and Water Supply Characteristics
8	Wells and Springs Location Map
9	Potentiometric Elevation Contour Map of the Intermediate Aquifer
10	Potentiometric Elevation Contour Map of the Deep Aquifer(s)
11	Project Site Map Showing Original Shoreline and 1915 Fill Limits
12	Project Site Geologic Map
13	Project Site Geologic Cross Sections X-X', Y-Y', and Z-Z'
14	Water Table Elevation Contour Map for the Fill Groundwater Unit
15	Study Site Showing Storm Drainage System
16	Surface Water Drainage Routed to Evaporator
17	Demolition Plan

## LIST OF TABLES

<u>Table</u>		Page
1	Composition of copper reverberatory slag	30
2	Summary of previous chemical analyses by ASARCO (Period: November 1984 to May 1985)	35
3	Ambient arsenic concentrations (ug/m <sup>3</sup> )	.54

#### 1.0 INTRODUCTION

The objectives of the Remedial Investigation/Feasibility Study for the ASARCO Tacoma Smelter are:

- (1) to determine fully the nature and extent of the threat to the public health or welfare or the environment caused by the release or threatened release of hazardous substances, pollutants or contaminants from the site (the remedial investigation), and
- (2) to evaluate alternatives for the appropriate extent of the removal and/or site stabilization to prevent or mitigate the migration or release or threatened release of hazardous substances, pollutants, or contaminants from the site (the feasibility study).

As a first step in the remedial investigation, a scoping process was undertaken. Existing data was collected and evaluated, information on the history of the site was reviewed, and data needs established. This initial activity served to summarize and compile what is known about the site, and to provide a preliminary evaluation of data needs for full site characterization. In addition, preliminary identification of general response actions are addressed. This understanding of the site formed the basis for developing the sampling plans in Task 2: Plans and Management.

The Task 1 report is divided into the following sections:

- o Site Description
- o Site History
- o Nature and Extent of the Problem
- o Site Boundary
- o Initial Remedial Measures
- o Potential General Response Actions
- o Data Needs

#### 2.0 SITE DESCRIPTION

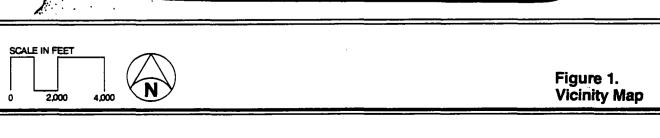
#### 2.1 Facility Ownership and Description

ASARCO, Incorporated, a New Jersey Corporation, owns the ASARCO Tacoma Copper Smelter located in Ruston and Tacoma, Washington. Approximately 97 acres of land are owned by ASARCO, with the smelter facility occupying approximately 67 acres (see Figure 1). The site borders Commencement Bay, the Town of Ruston and nearby urban Tacoma. Surrounding land use is primarily suburban residential with nearby recreational and commercial land uses.

The Tacoma plant site had been used for smelting operations since 1890. In March 1985, the smelter was closed due to poor economic conditions for copper smelting and high pollution control costs. The arsenic plant remained in operation through January 1986. Existing activity on the site consists of loading arsenic trioxide for shipment, acid sales, dismantling of equipment for sale or storage, maintenance and administrative functions, and cleanup activities specified in the Site Stabilization Plan approved by EPA as an Initial Remedial Measure (Attachment A to the Administrative Order on Consent).

During the active life of the Tacoma plant, its primary product was anode copper which was refined on-site until 1979. Since that date and until closure of the smelter operations in 1985, the anode copper was rail-hauled to an ASARCO refinery in Texas. By-products of the copper smelting process included sulfuric acid, liquid sulfur dioxide, arsenic trioxide, and arsenic metal. In addition, the smelting process created a molten slag which was poured on the ground and at the water's edge as fill material. Recovery and sale of slag for use in sandblasting, riprap, road ballast and ornamental rock was handled by Industrial Mineral Products, Inc.

An understanding of the copper smelting process, the components of the plant, and how/where specific functions took place provide a basis for determining



appropriate remedial actions. Figure 2 shows existing or recent buildings on the site. Figure 3 is a flow diagram of the smelting process.

The following description of the copper concentrate smelting process was taken from ASARCO's fact sheet on the plant:

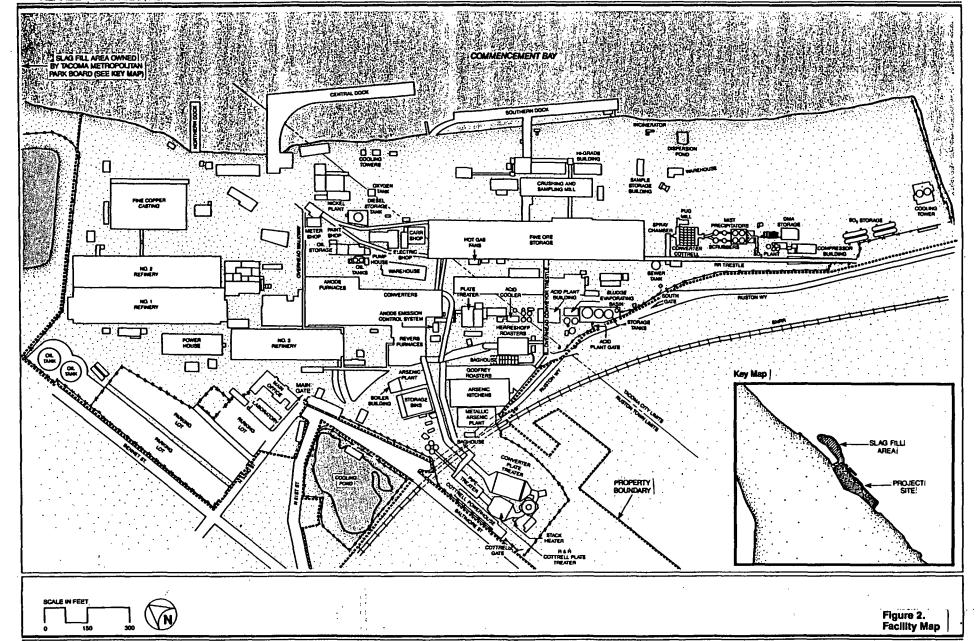
#### COPPER CONCENTRATE SMELTING PROCESS

Copper-bearing ores and concentrates, along with the various fluxing materials used in the process, were received in the unloading area. Each material was carefully weighed and sampled so that an accurate accounting of the material could be maintained.

The various materials were placed in large bins inside the 40,000-ton storage building. Utilizing the assays of the material in each bin, and knowing the desired charge make-up, the furnace metallurgist provided a recipe of materials required for the craneman to place in the mix pile and ultimately on the belts to the Herreshoff roasters.

The Herreshoff roasters are large 20-foot diameter cylindrical furnaces about 70 feet tall with multiple decks on which air cooled arms rotate and plow the material to either the inside or outside of the deck. The material was heated as it moved downward on successive decks and some sulfur driven off. The resultant product, known as calcine, was run into small cars that hauled the calcine to the reverberatory furnace.

The reverberatory furnace is a large rectangular refractory lined box about 115 feet long, 35 feet wide and contained molten material to a depth of about 50 inches. The calcine was charged to the furnace through pipes on the side of the furnace. Smelting of the charge mixture resulted when heat from the seven oil or gas fired burners contacted the charge. The temperature was about 2800°F. The temperature at the back end of the furnace where the uptakes



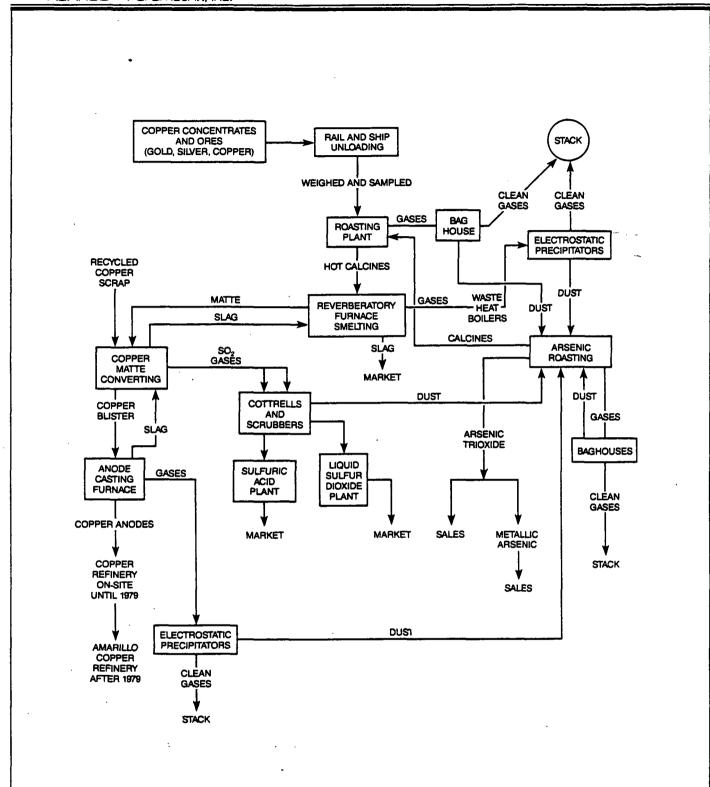


Figure 3. Process Flow Diagram

directed the gases through waste heat boilers for the production of steam reached about 2500° F. The metallurgical reactions deposited the copper-iron-sulfide mixture, or matte, as the bottom layer of molten material with the slag consisting of iron silicates floating on top. The slag was skimmed in ladle type cars for transport to the slag dump. The matte, which contains copper, gold, silver, and small quantities of various other metals, was carried in 15-ton capacity ladles by overhead cranes to the converters for further purification.

The converters are refractory-lined, steel-shelled, cylindrical vessels approximately 13 feet in diameter and 30 to 35 feet long. The converters could be rotated about the long axis. Low pressure air (15 psi) was blown through the bath to drive off the sulfur and to oxidize the iron. The reaction in the converter is exothermic, that is, it creates its own heat as the air oxidizes the molten material. The resulting product, blister copper, was about 98% copper and was transferred to the anode furnaces for further purification. The slag which was skimmed off the converter was returned to the reverberatory furnace as it contained some copper.

The anode furnaces are refractory-lined, steel vessels of about 150 to 170-ton capacity. Blister copper was poured into the furnaces using the large overhead cranes. The blister copper was refined using chemicals and then the excess oxygen was removed by submerging "green" poles in the hot blister bath to reduce the blister to copper. Then, the copper was cast into anodes by tilting the furnace so as to pour the copper into anode molds. The anodes weighed about 750 pounds each and were shipped to the Amarillo Copper Refinery from 1979 until plant shutdown. Before 1979 an electrolytic refinery located on-site was used to refine the copper anodes.

The gas streams from the reverberatory furnace and the anode furnaces passed through the electrostatic precipitators at the base of the stack which collected the dust. This dust and the dust collected in the large baghouse (a huge vacuum cleaner) on the Herreshoff roasters made up the charge for the arsenic oxide plant. These dust collection devices recovered 99+ percent of the dust in the gases. Roasting this dust produced a by-product of salable arsenic trioxide. Also, arsenic metal was produced from arsenic trioxide.

The gases from the converter operation were of a concentration and volume that sulfur dioxide (SO<sub>2</sub>) could be removed in the chemical plants.

Supplemental Control System (SCS) and Meteorological Curtailment Program (MCP) were instrumental in enabling the Tacoma Plant to comply with Federal, State, and local regulations regarding ambient air standards for sulfur dioxide. This program and associated system was implemented in 1970 to monitor, predict and respond to meteorological conditions which were not conducive rapid dispersion of SO<sub>2</sub> emissions. When forecasted meteorological conditions were unfavorable for production curtailment could be initiated so that ambient air quality could be maintained. The program required the development of an Emission Control Center with a staff of meteorologists and Monitoring stations at the facility generated data technicians. which were computerized and compiled with other meteorological data from the Tacoma area as well as data on plant operations to forecast potential air quality problems.

#### POLLUTION CONTROL FACILITIES:

<u>Cottrell Electrostatic Precipitators</u>: First installed in 1915 for removal of particulate matter in the smoke stream, this installation was modernized many times over the years and is 99.5% efficient.

<u>Sulfuric Acid Plant</u>: Built in 1948, this plant produced 100 to 150-tons of acid per day removing about 17% of the process sulfur.

<u>Liquid Sulfur Dioxide Plant</u>: Built in 1974, this plant removed sulfur dioxide from the converter gas stream and compressed and condensed it to a liquid form at a daily rate of about 150 tons of liquid sulfur dioxide.

<u>Sewage Collecting System</u>: Constructed in 1971, the system was connected to the City of Tacoma system when the primary treatment plant on Ruston Way was completed.

<u>Process Water Recirculation System</u>: Built in 1974, this system was designed to recycle all process water to prevent discharge into Puget Sound.

<u>Cottrell Dust Handling System</u>: Installed in 1975, this system handled all dust in completely closed and ventilated systems.

<u>Herreshoff Roaster Baghouse</u>: Installed in 1978 for processing roaster gases.

<u>Anode Emission Control System</u>: Installed in 1979 for dust removal from all anode gases.

<u>Godfrey Roaster Baghouse</u>: Installed in 1983 for processing arsenic department gases.

<u>Converter Secondary Hooding</u>: Installed on the No. 4 converter in 1982 to reduce fugitive emissions from converters.

Godfrey Calcine Conveying System: Installation during 1983 to convey Godfrey roaster calcines to the Herreshoff roasters in a totally enclosed system.

#### 2.2 Hydrogeology

This section presents an evaluation of the regional and project site hydrogeologic conditions for the ASARCO-Tacoma facility. The regional hydrogeology subsection contains a description of regional geologic units, and their hydrogeologic, water supply and water quality characteristics.

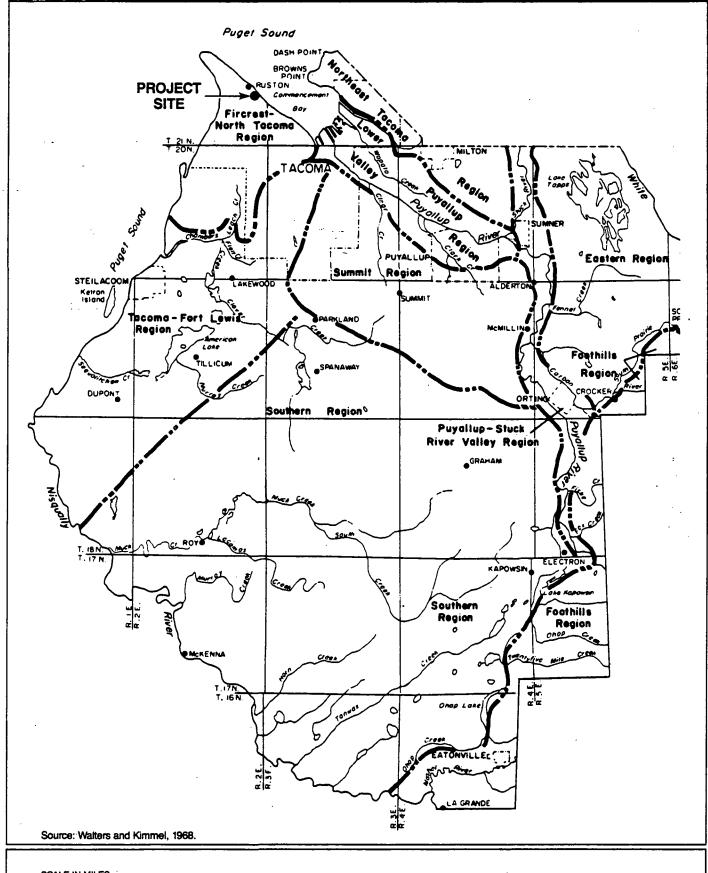
The hydrogeology of the project site is presented in the second subsection. The geologic units presented for the project site area are identified and correlated to the regional geologic units. Specific site conditions pertaining to groundwater flow and water quality are discussed.

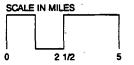
### 2.2.1 Regional Hydrogeology

For the purpose of this evaluation, the discussion of regional geology is limited to the known geology in a portion of the "Fircrest-North Tacoma" groundwater region, as defined by Walters and Kimmel (1968), and depicted on Figure 4. The entire Fircrest-North Tacoma area is underlain by roughly similar geologic and groundwater conditions. Much of the region is a poorly drained upland drift plain of moderate relief, ranging in altitude from about 200 to 400 above sea level. The region is underlain by unconsolidated sediments that extend to a depth well below sea level. The upper portion of the upland drift plain was formed by glacial and glaciofluvial processes which deposited till and outwash. The drift plain is terminated on the north, east and west by Puget Sound which is the regional groundwater discharge point.

## 2.2.1.1 Stratigraphy

Several regionally recognized geologic units are present in the Fircrest-North Tacoma Region which comprise the regional stratigraphy. The character of these units was assessed based on description of surface exposures and well log data. The following is a description of the geologic units, presented oldest to youngest, that occur in the region with emphasis on the hydrogeologic characteristics of each unit. A Regional Geologic Map,







Groundwater Region Boundary

Figure 4.
Groundwater Regions

Geologic Cross Sections and a Summary of Regional Geologic Units and Groundwater Characteristics are presented on Figures 5 through 7.

#### Pre-Salmon Springs Undifferentiated (Qpu)

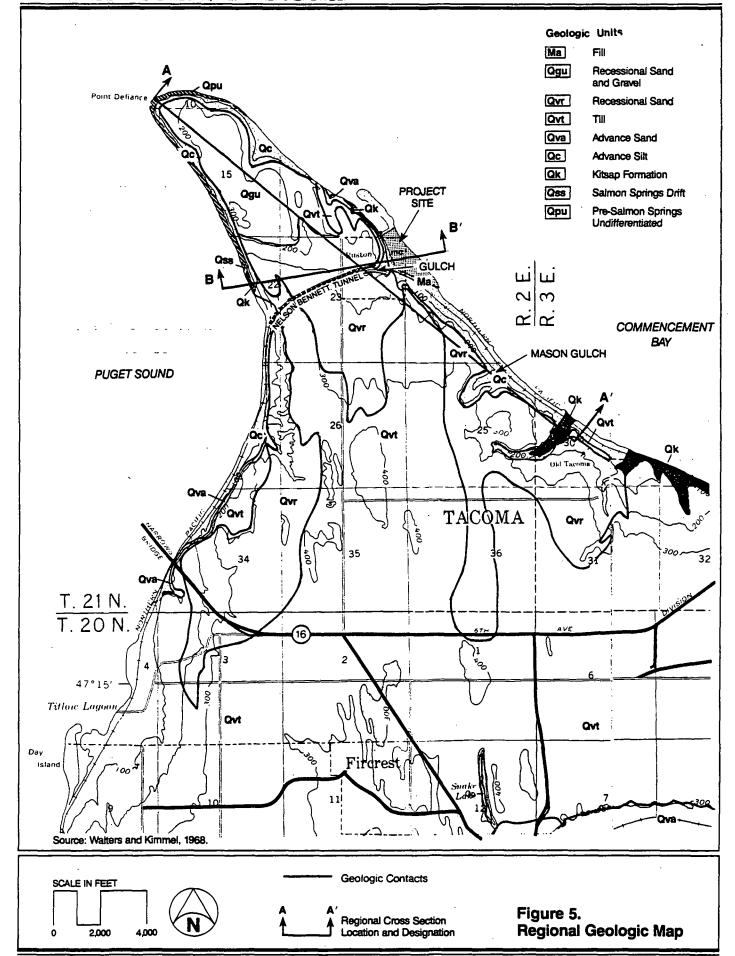
Pre-Salmon Springs undifferentiated deposits consist of unconsolidated evenly bedded blue clay that locally contains peat and thin beds of fine sand. These deposits are exposed at or near sea level in the north end of the region. The thickness of the clay and underlying unconsolidated deposits of interbedded sand and gravel (unknown age) is in excess of 2000 feet (Griffin et al. 1962). These deposits are thought to pre-date Salmon Springs Drift (see below) but no attempt is made to subdivide or correlate these deposits. These deposits may yield water to deep wells that extend below the clay.

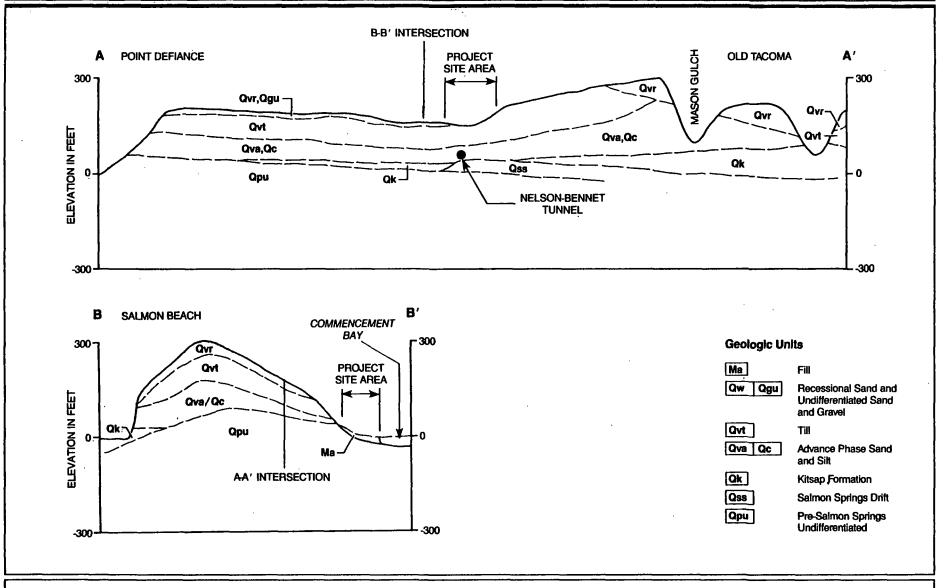
### Salmon Springs Drift(?) (Qss)

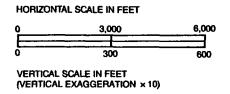
Salmon Springs Drift consists mostly of stratified sand and gravel containing thin discontinuous beds of silt and clay. Lenses of till are present but no extensive till sheet has been observed. The unit is tentatively correlated to Salmon Springs Drift of Crandell et al. (1958). Locally the finer grained portions of the unit act as a barrier to downward percolation of groundwater, and lateral movement of water along its upper surface is responsible for numerous springs in other areas of the western Puget lowland. Stratified sand and gravel within Salmon Springs Drift acts locally as a productive aquifer. Within this region, the unit has limited surface exposure and its subsurface extent is unknown.

#### Kitsap Formation (Qk)

The Kitsap Formation consists of three parts; sand and gravel at the base, fine sand and silt in the middle, and clayey sand and gravel at the top (Sceva 1957; Molenaar 1965). The basal gravel is relatively free of silt and clay, is of unknown thickness, and is overlain by beds of clay, silt and fine sand







Notes: 1. Refer to Figure 5 for Cross Section Locations

- 2. Refer to Figure 7 for Explanation of Geologic Units
- Geologic Interpretation Based on Mapping by Walters and Kimmel, 1968.

Figure 6.
Regional Geologic
Cross Sections A-A' and B-B'

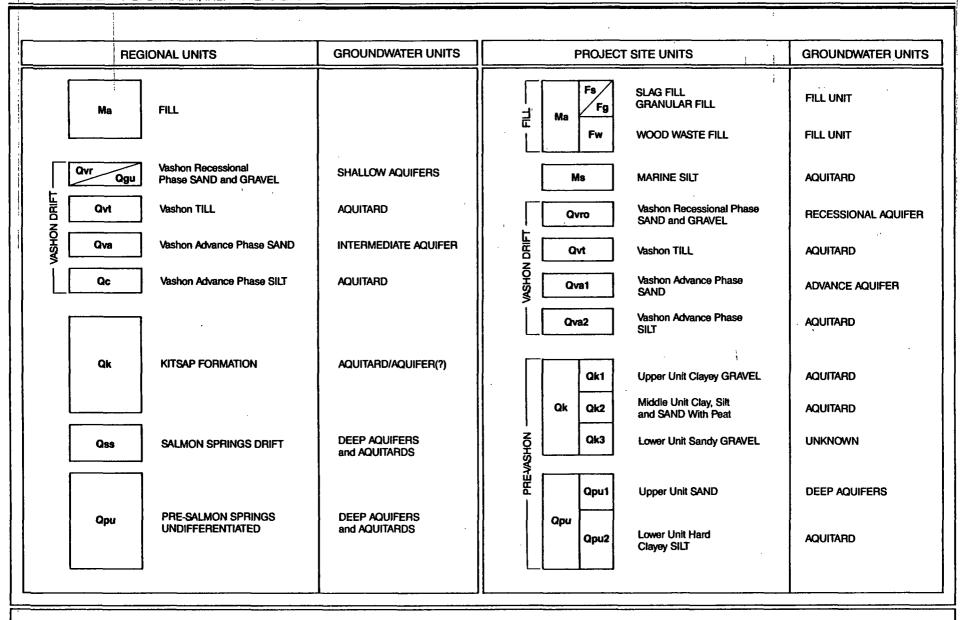


Figure 7.
Summary of Regional and Project Site
Geologic Units and Groundwater Characteristics

(middle unit). The upper portion of the Kitsap Formation is mainly a clayey gravel. The maximum observed thickness of the entire unit is 150 feet.

The lower unit (basal gravel) of the Kitsap Formation contains beds of relatively permeable sand and gravel which are probably capable of yielding a significant amount of water to wells where saturated. The middle and upper unit of the formation are too fine-grained for them to be good aquifers and locally they retard the downward migration of groundwater from the overlying Vashon drift.

#### Vashon Drift

The Kitsap Formation is overlain by a variable thickness of drift deposited during the Vashon stade of the Fraser Glaciation (Armstrong et al. 1966). The drift records the advance and retreat of glacier ice into the Puget Lowland between 17,000 and 13,500 years ago. Vashon Drift, as described here, consists of an advance phase and a recessional phase.

#### Advance Phase (Qc, Qva, Qvt)

The advance phase consists of a geologic sequence of variable thickness that is divided into three units, a basal lacustrine silt and clay unit (Qc), grading upwards into a sand and minor gravel unit (Qva), and a till unit (Qvt). The basal silt and clay unit is thinly bedded, gray in color, and of relatively low hydraulic conductivity.

The top of the silt and clay unit progressively grades into a clean fine to medium sand unit (Colvos Sand of Noble and Wallace 1965). The sand unit grades vertically to fine to coarse gravel. Advance phase outwash deposits range from 0 to over 100 feet in thickness.

The Vashon basal lacustrine silt and clay unit (Qc) acts as an aquitard which retards the vertical migration of groundwater from overlying sand and gravel. Advance phase sand and gravel (Qva) is the most important source of supply for domestic wells in much of the region. Water from this unit locally

discharges as springs in valleys and beach bluffs where underlain by advance lacustrine silt and clay or other deposits of lower hydraulic conductivity.

Till (Qvt) deposited at the end of the advance phase is presently occurring throughout most of the region as a "blanket deposit" mantling older units. The till unit is a very compact (dense), poorly sorted mixture of gravel, sand, silt and clay. Till is an inadequate source of groundwater due to the high silt and clay content and degree of compactness.

### Recessional Phase (Qvr. Qgu)

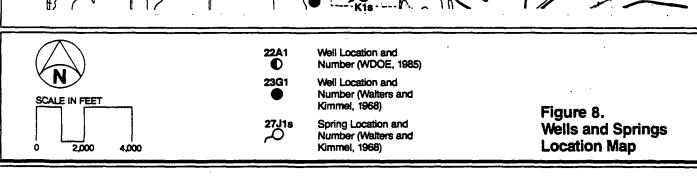
The recessional phase of the Vashon drift consists chiefly of sand (Qvr) and sand and gravel (Qgu). These deposits overlie till and occur at the ground surface. The sand and gravel unit is generally well drained and loose. Most shallow wells in the vicinity tap groundwater in this unit perched on till. Water supply is directly influenced by rainfall and supply of water may not be enough to last through dry seasons.

#### 2.2.1.2 Water Supply

Wells in the region tap groundwater bearing zones (aquifers) in the geologic units previously described. The geologic units have been divided into three aquifers (shallow, intermediate, deep) for discussion purposes as shown on Figure 7. Figure 8 shows the locations of existing wells and springs in the region used in this study. These wells were compiled from literature research and review of state well records. Other unrecorded wells may be present in the area.

# Shallow Aquifer

The shallow aquifer in the region, as used herein, occurs in the recessional phase sand and gravel unit, perched on or in till. Regionally, this aquifer yields low quantities of water to wells. During the drier portions of the year, shallow wells which tap the shallow aquifer unit may "dry up".



### Intermediate Aquifer

The intermediate aquifer consists of the advance phase sand and gravel unit which occurs in a zone ranging from about 100 to 250 feet above sea level. Wells that tap the intermediate aquifer are very productive, yielding moderate to large volumes of water. The average hydraulic conductivity of this aquifer has been reported to be about 0.01 to 0.05 cm/sec (Brown and Caldwell 1983).

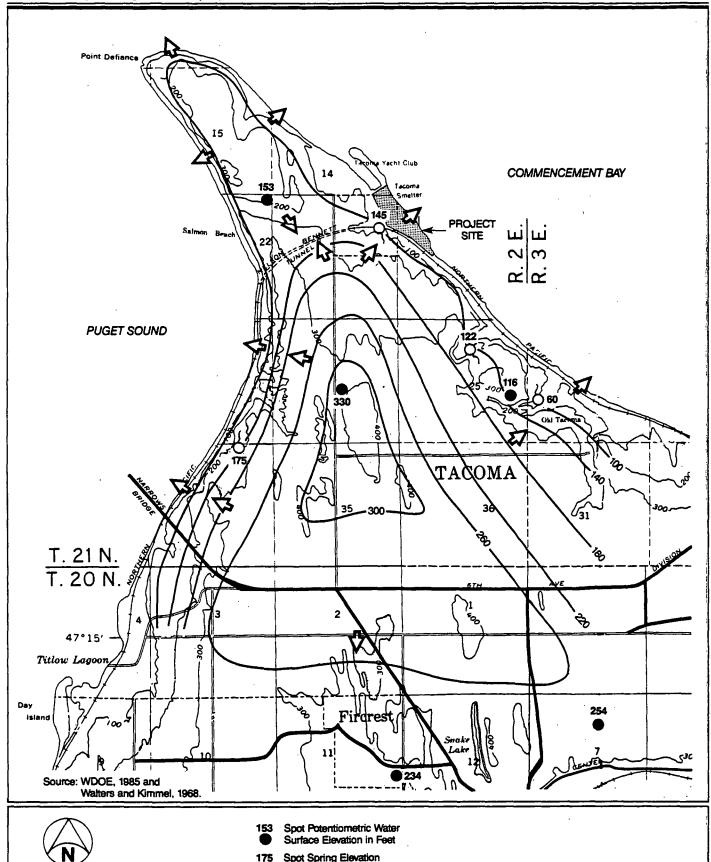
Groundwater from this aquifer discharges as springs where these units rest on low permeability silt and clay and are truncated by sea cliffs or stream channels. The two largest springs are Mason Gulch Spring (used by the City of Tacoma until 1930) and an unnamed spring to the south. These two points serve as examples of points of groundwater discharge in the region. The intermediate aquifer appears to be predominantly confined.

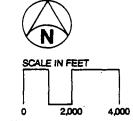
### Deep Aquifer(s)

Water from the deep aquifer(s) is obtained from gravelly zones that extend from about sea level to a depth of 100 feet or more below sea level. These aquifers occur in Salmon Springs Drift(?) or older unconsolidated deposits and are generally confined. Wells tapping these aquifers yield moderate to large volumes of water.

### 2.2.1.3 Groundwater Flow, Recharge and Discharge

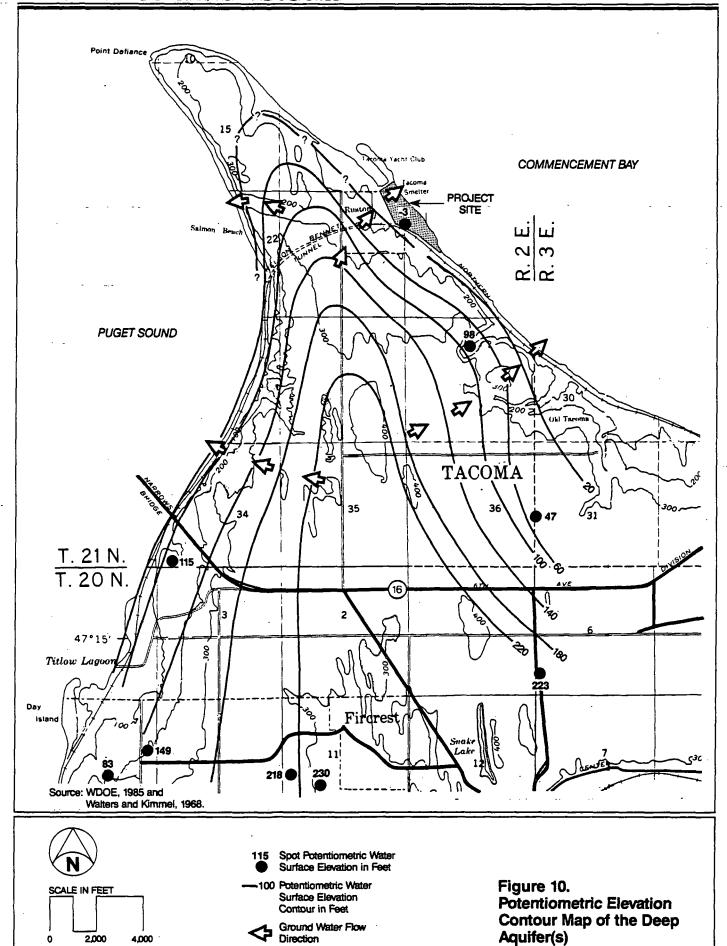
Potentiometric surface maps for the intermediate and deep aquifers are presented on Figures 9 and 10. The contours shown are based on linear interpolations between known point values of potentiometric head elevations and interpretation of the regional geology. Groundwater flows generally perpendicular to the groundwater elevation contours. The potentiometric head values were estimated from data contained in existing reports (WDOE well records, Brown and Caldwell 1983, Walters and Kimmel 1968).





- 175 Spot Spring Elevation on Feet
- —180 Potentiometric Water Surface Elevation Contour in Feet
- Ground Water Flow Direction

Figure 9.
Potentiometric Elevation
Contour Map of the
Intermediate Aquifer



The maps indicate that the predominant groundwater flow direction within both the intermediate and deep aquifers occurs toward the Tacoma Narrows, Puget Sound and Commencement Bay. The average head elevations in the intermediate aquifer appear to be higher than that of the deep aquifer indicating the potential for downward movement of groundwater from the intermediate to the deep aquifer in the upland area.

Recharge to the shallow and intermediate aquifers occurs through infiltration and downward percolation of local precipitation based on geology and configuration of the intermediate aquifer potentiometric surface. Recharge rates from local precipitation are estimated to be on the order of 7 to 16 inches per year (Hart Crowser 1985).

Recharge to the deep aquifer occurs from local vertical percolation of groundwater from the intermediate aquifer and lateral groundwater migration from the southern portion of the Region. This conclusion is based on the configuration of the deep aquifer potentiometric surface, higher groundwater elevations in the intermediate aquifer as compared with the deep aquifer, and experience in other geologically similar areas.

Groundwater discharge occurs by spring flow and subsurface groundwater flow into small tributaries and Puget Sound. Shoreline areas located along the perimeter of the Fircrest-North Tacoma Region likely are groundwater discharge zones. In these areas, it can be expected that vertical hydraulic gradients in the deeper deposits (deep aquifer) will be in an upward direction. This is supported by the occurrence of several wells which naturally flow at the surface if left uncapped (Walters and Kimmel 1968). Flowing wells are not shown on Figure 10 and were not used in the construction of Figure 10.

### 2.2.1.4 Groundwater Quality

The available regional water quality data are summarized in DSHS (1980) and Brown and Caldwell (1983). The following paragraphs are a brief summary of the results of these studies.

The natural, regional groundwater quality is good and is generally within Washington State Drinking Water Standards for Class 1 water systems. However, based on our experience with glacial deposits in other areas of Puget Sound, iron and manganese concentrations commonly exceed drinking water standards and these exceedances may be present in the region.

The water quality in the region has declined in recent decades as a result of urbanization as indicated by increased levels of nitrates, chlorides, and total dissolved solids. The regional shallow and intermediate aquifers have experienced an increase in contaminant levels, indicating that both aquifers are vulnerable to contamination although no specific data exists for the project area.

The shallow aquifers are the most highly susceptible to potential contamination because in many areas there is no overlying, continuous, geologic barrier to restrict downward migration of contaminants. The shallow aquifers can also be an avenue for potential contamination of the intermediate aquifer systems where underlying low permeability geologic units do not occur. The deeper aquifers are less susceptible to direct contamination.

#### 2.2.2 Project Site Hydrogeology

Site specific variations in topography, stratigraphy, and man induced modifications influence the site hydrogeology. The project site hydrogeologic conditions are generally similar to regional conditions, although site specific variations exist.

Hydrogeologic interpretations presented in this section are based on preliminary findings and conclusions drawn from analysis of existing subsurface data, published geologic reports, previous site specific geologic mapping and other available data. These interpretations are subject to change as additional data become available. This section contains a

description of the site topography, stratigraphy, aquifers, groundwater flow, and water quality.

#### 2.2.2.1 Topography

Many of the smelter facilities are located on reclaimed tide flats at the base of sea cliffs on Commencement Bay. The sea cliffs are composed mostly of advance phase deposits of the Vashon stade (glacial recession) and rise from sea level to an elevation of about 200 feet. A reentrant in the sea cliffs is present in the middle of the facility and structures are present on the sea cliffs on either side of the reentrant (Figure 5).

The former tidelands at the base of the sea cliffs were gradually reclaimed by the placement of fills. Fill materials include wood chip/saw dust waste, used brick in a sand matrix, and smelter slag. Fill materials have been placed to an elevation of about 20 to 25 feet (MSL) on reclaimed tideland. The approximate position of historic and pre-development shorelines are presented on Figure 11 as determined from old plant drawings and interpretation of subsurface data.

The topographic reentrant in the sea cliffs has been modified by street and railroad construction, and little of its original surface expression is preserved. The reentrant takes the form of a gulch (Figure 5) with a floor elevation of about 50 feet, although the gulch is not supported by a significant drainage basin. This gulch is thought to have been formed by spring sapping and subsequent erosion (spring sapping is a geologic process that occurs when springs discharging from the base of slopes result in locally unstable conditions and the slope responds by slumping and retreat).

### 2.2.2.2 Stratigraphy

For purposes of this discussion, the stratigraphy of the project site is presented in four functional area groupings ordered from oldest to youngest; the pre-Vashon geologic units exposed and at present below sea level, Vashon units exposed above and encountered below sea level, post-Vashon units

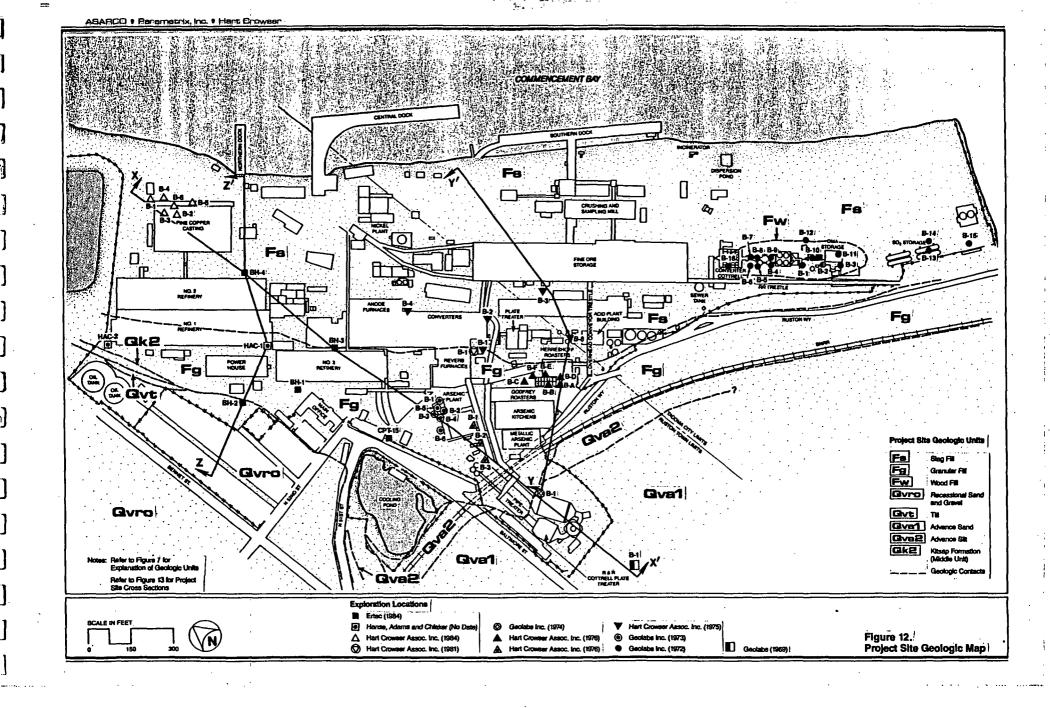
present below sea level, and fills. The surficial geology of the project site is presented on Figure 12. Geologic cross sections of the site are presented on Figures 12 and 13. A summary of the project site geologic units and groundwater characteristics is presented on Figure 7. The cross sections were prepared using boring log data contained in site geotechnical reports. Boring locations and data sources are presented on Figure 11.

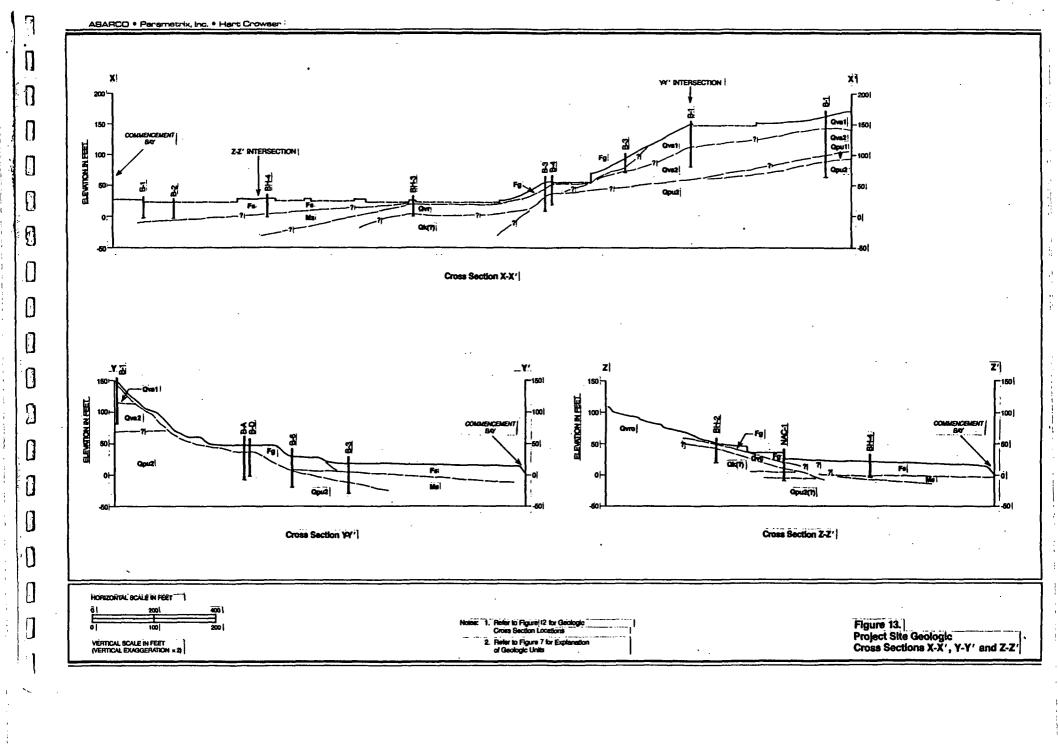
### Pre-Vashon Geologic Units (Qpu/Qk)

Pre-Vashon age geologic units beneath the project site consist of a saturated sand overlying hard silt (Qpu), and hard, peaty, sandy silts overlying gravel (Qk) and hard clay. These deposits were encountered in deep and shallow borings in the eastern portion of the project site and are exposed at sea level and in shallow borings in the western portion of the project site, respectively.

Saturated sand (Qpul) overlying hard silt (Qpu2) was encountered in borings (greater than 100-feet deep) on top of the sea cliffs in the southern portion of the project site. The sand unit is tentatively correlated to similar deposits exposed to the west at Salmon Beach and to the north along the beach on Point Defiance (Figure 5) all of which are interpreted to be pre-Salmon Springs age. Where encountered, the saturated sand unit is about 10 to 15 feet thick. The hard silt unit is in excess of 60 feet thick. Existing subsurface data suggest that the dip of the erosional surface of these deposits is to the east and north. These units do not appear to have been encountered in shallow borings in the western one-third of the project site.

A hard, peaty, sandy silt unit overlying gravel and a hard clay unit are exposed near sea level and encountered in shallow borings in the western one-third of the project site. These units are tentatively correlated to the Kitsap Formation (Qk).





#### Vashon Geologic Units

The geologic units exposed at the project site were generally deposited during the advance and recessional phases of the Vashon stade of Fraser Glaciation. The silt unit (Qva2) of the advance phase is exposed at sea level up to an elevation of about 150 feet. The top of the silt unit is delineated in the field by the occurrence of springs. This silt unit is overlain by as much as 60 feet of the fine to medium sand (Qval) of the advance phase sand unit which occurs up to elevations of 200 feet. Till (Qvt), which occurs stratigraphically above the silt and sand units, is present at low elevations in the western portion of the project site and is not observed in depositional contact with the advance silt and sand units. The recessional phase sandy gravel unit (Qvro) overlies the till unit.

### Post-Vashon Geologic Units

Post-Vashon geologic deposits in the project area are chiefly marine silt and sandy silt and are considered as one unit (Ms). The deposits occur below man-made fills that comprise the reclaimed tide land portion of the site. Fills are described separately. The marine silt contains shell fragments and abundant organic material. The estimated landward extent of the marine deposits is presented on Figure 12. Seaward thickening is indicated by subsurface data.

#### **Fills**

Three general classes of fills have been identified beneath the project site which include: smelter slag (Fs), granular fill with brick waste (Fg), and wood waste (Fw) (Figure 12). Slag has been used for reclaiming tide lands and for road base. The textural and compositional characteristics of the slag fill is extremely variable. Slag is known to be in excess of 30 feet thick on the east edge of the bay fill and thins to the west.

Granular fill has been observed in borings near the base of the sea cliffs and consists of placed fills and construction debris. Fill consists of silty

sand with bricks to gravelly sand. The distribution, thickness and composition of these fills is only generally known.

Wood waste fill consisting of saw dust and wood chips has been observed in borings on the southern portion of the reclaimed tide landfill. Wood waste fill, as encountered in borings, ranges from 2 to 12 feet thick. The wood waste is overlain by as much as 15 feet of slag.

### 2.2.2.3 Subsurface Soil Quality

Information regarding subsurface soil quality on the project site has not been identified. However, considerable information is available regarding the chemical composition of the slag. The copper reverberatory slag that comprises a major subsurface unit beneath the site is predominantly a glassy ferrosilicate with variable trace metal content. The chemical composition of the slag is summarized in Table 1.

Table 1. Composition of copper reverberatory slag.

	Ave.		
Element	Conc'n. X	High %	Low X
Lead	.63	.86	.36
Copper	.51	.59	.43
Zinc	2.48	2.92	1.45
Arsenic	1.15	1.47	.89
Antimony	.47	.68	.34
Nickel	.05	.08	.03
Silicate (as SiO <sub>2</sub> )	37.7	38.6	36.6
Iron	32.7	33.0	31.9
Calcium (as oxide)	7.5	8.0	6.6
Sulfur	0.4	0.8	0.1
Magnesium (as oxide)	1.48	1.66	1.00

Source: ASARCO Material Safety Data Sheet (1982)

The composition of subsurface slag is likely similar to that of slag samples previously tested. Post-depositional alteration may have resulted in chemical changes to the subsurface slag. Additionally, surface discharges of chemicals may have influenced subsurface soil quality.

### 2.2.2.4 Groundwater Units

The site materials have been divided into four groundwater units for discussion purposes. These include: fill unit, shallow aquifer, intermediate aquifer, and deep aquifer.

### Fill Unit

The fill groundwater unit as defined herein lies within the three types of fills identified on the site. The hydrogeologic characteristic of the fill is heterogeneous due to the variable textural and compositional make up. The unit is recharged from lateral discharge of groundwater from the shallow and intermediate aquifers and infiltration from direct precipitation. Groundwater flow in this aquifer is likely influenced by tidal fluctuations in Commencement Bay. The fill groundwater unit is interpreted to overlie recent marine silts and other older units.

#### Recessional Aquifer

The recessional aquifer is the Vashon recessional phase sandy gravel unit (Qvro) which rests on till. Groundwater in this aquifer is perched on underlying till. This aquifer is restricted to the northwest portion of the project site that approximately coincides with the parking lots and administration buildings.

#### Advance Aquifer

The Vashon advance phase sand unit (Qval) is the advance aquifer in the project site area. The aquifer occurs in the sea cliffs and extends from an elevation of about 60 feet up to an elevation of 200 feet and occurs south of

the Nelson-Bennet Tunnel. Groundwater from this aquifer discharges as springs along the railroad tracks that approach the tunnel, in the gulch, and at similar elevations around the sea cliffs to the south.

### Deep Aquifer(s)

Little is currently known about deeper aquifers beneath the project site. A suspected confined aquifer, the upper sand unit of pre-Salmon Springs deposits (Qpul), occurs in the upland above the project site between 80 to 100-feet in elevation. The potential for aquifers to be present within the Kitsap Formation (Qk) also exists.

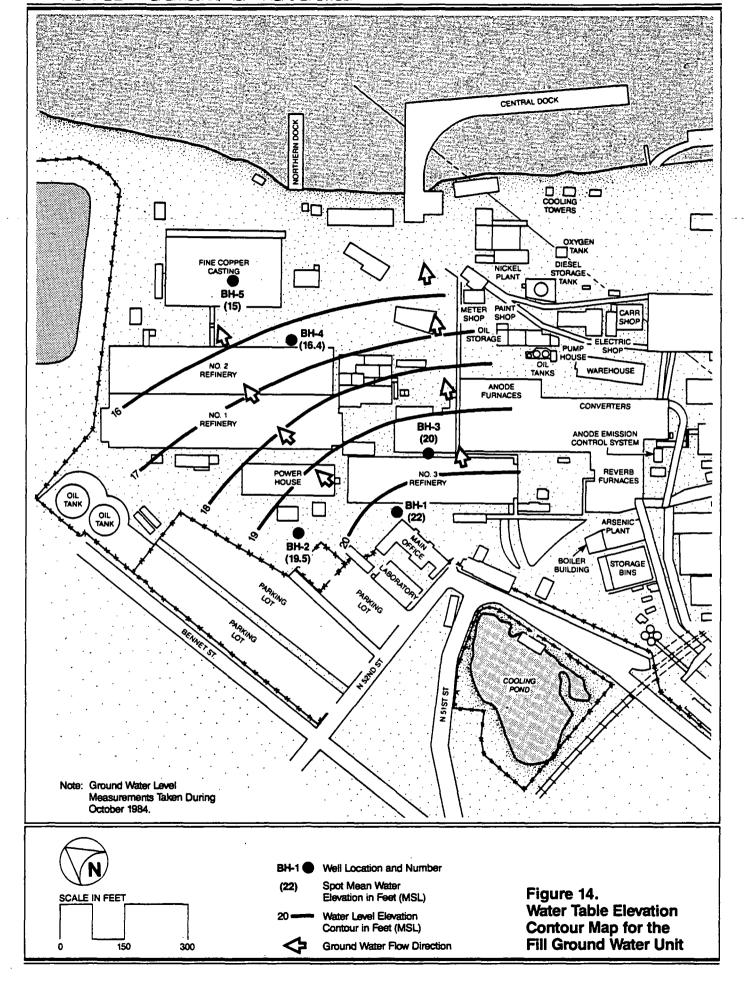
### 2.2.2.5 Groundwater Flow

The site geologic conditions and other available data indicate that groundwater beneath the site flows toward Commencement Bay. Flow generally occurs within the relatively higher permeability materials (Fills, Qvro, Qval) which overlie lower permeability silt and clay (Qpu2, Qk, Qva2).

Recharge to the site occurs through infiltration of precipitation (not collected as runoff) and as lateral flow of groundwater onto the site from the Vashon advance and recessional aquifers. Groundwater flow flows onto the site either as surface flow or as spring discharge where the contacts between "low" and "high" permeability materials are exposed at the surface.

Based on water table measurements (ERTEC 1984), a conceptual water table contour map for the fill was developed for the western portion of the site (Figure 14). The contours shown are based on the linear interpolation between point values of water elevations using measurements made during October 1984. Similar water table configuration likely exists for the middle and eastern portions of the facility.

Interpretation of the water table map indicates that groundwater flow occurs toward Commencement Bay. However, groundwater conditions in deeper aquifers are not known. Based on the site location with respect to the uplands and



Puget Sound, groundwater flow within the deep aquifer is likely to be in an upward direction towards the Sound.

### 2.2.2.6 <u>Water Rights and Wells</u>

Filed water rights obtained from WDOE for the region indicate that no water rights are deeded for the project site. There are no water wells on the project site.

### 2.2.2.7 Groundwater Quality

Groundwater quality measurements including pH, dissolved arsenic, antimony, cadmium, copper, lead, and zinc analyses were taken from five shallow groundwater monitoring wells during late 1984 and early 1985. Results of these analyses are summarized in Table 2. The data in Table 2 suggest that wells downgradient of refineries generally have elevated concentrations of metals compared to wells upgradient of refineries. However, large variations in concentrations and variable pH values are observed. The reason or reasons for the large variations in concentrations over the cause of time have not been determined but may be related to variations in sampling.

Table 2. Summary of Previous Chemical Analyses by ASARCO (Period: November 1984 to May 1985)

# METAL CONCENTRATIONS (mg/L)

Well Number	рH	As	Sb	<b>cd</b>	Cu .	Pb
1	5.9-7.3	<0.50-1.00	<0.50-0.70	<0.01	<0.01-0.88	<0.02-0.62
2	6.5-9.7	<0.50-0.55	<0.50-1.00	<0.01-0.02	<0.01-1.14	<0.02-3.40
3	5.0-7.3	<0.50-5.0	<0.50-1.10	<0.01-0.07	0.04-36.00	<0.02-2.30
4	4.2-7.3	<0.50-10.70	<0.50-1.00	<0.01-0.02	<0.02-4.55	<0.02-1.00
5	6.0-7.2	<0.50-1.90	<0.50-0.90	<0.01-0.03	0.22-5.00	<0.02-2.40

#### 3.0 SITE HISTORY

### 3.1 History of Use of the Site

The ASARCO Tacoma smelter site was developed as a lead smelter in 1890. During the first decade, two roasters and associated bunkers were constructed, a briquetting machine and sheltering building were erected, and three blast furnaces and an electric power facility installed.

Copper ores had been smelted in one of the lead blast furnaces until 1902 when a dedicated blast furnace was built and a converter constructed. The blister copper produced at the Tacoma plant was refined at other sites until 1905. An electrolytic copper refinery and casting facilities were completed and the first shipment of copper ingots and ingot bars made in 1905. It was at this time that the facility was purchased by the American Smelting and Refining Company. The lead plant was closed down after ore shipments discontinued in 1911.

Changes in practices at the mines during the early 1900's resulted in increased concentrating of ores before shipment to the smelter. This created more finely ground materials which were difficult to handle in the furnaces. A brick machine was developed to produce bricks of concentrates and binder for easier handling in the blast furnaces. This method was utilized until 1930 when the blast furnaces were shut down.

During the period from 1913 through 1917, the entire plant was practically rebuilt. Some of these improvements included the addition of a third copper blast furnace, a reverberatory furnace to handle the fine concentrates with six Herreshoff roasters as necessary equipment for its operation, and two additional converters to handle the matte produced. The original electrolytic tankhouse was enlarged and two new ones added. Receiving and storage facilities were mechanized.

At this time, the stack on the hill was built. It originally towered 571 feet above the base. Later, due to deterioration of the terra cotta cap, it

was shortened to 562 feet. The first industrial electrostatic precipitators were built to trap the fine ore particles carried by the smoke stream before it entered the stack. Two electrostatic precipitators (ESP's) were installed near the main stack in 1915, and were modernized several times. The No. 1 precipitator cleaned gas streams from the reverberatory furnace. The No. 2 precipitator cleaned gases from the ventilation systems (e.g. slag launders), and the anode furnaces after installation of the Herreshoff roaster baghouse. Most of these improvements were occasioned by the requirements of furnace capacity to treat the tonnage from the Kennecott Mine on the Copper River in Alaska.

The next important improvement was the building of a new ore receiving wharf in 1923. This included erection of two large Gantry cranes which travelled along the wharf and dug ore from the holds of ships. They discharged onto conveyor belts running the length of the wharf which carried the ore to weighing and sampling hoppers and thence to either the crushing plant, or in the case of concentrates, to weighing, and then both ore and concentrates to storage.

Decrease in coarse ore receipts and increase in the finely ground concentrates gradually brought about the necessity of adding a second reverberatory furnace. This was built in 1929. Blast furnace smelting operations were discontinued in 1930. Coarse ore, formerly handled by the blast furnaces, was crushed and smelted in the reverberatories.

Ores were crushed and samples cut mechanically. Then the crushed materials were transported to storage by belts. Proper mixing of the correct proportion of different types of materials followed to produce a charge that would smelt as easily as possible and result in the desired matte and slag.

The charge was then roasted to preheat it and prepare it for smelting. The actual smelting, which was accomplished in a reverberatory furnace, was a melting process forming matte, a copper-iron-sulfur mixture, which settled to the bottom. As it settled it gathered any gold and silver contained in the charge. The slag floated on the matte and was skimmed off and dumped. Much

of the area on which the plant is built was formed by slag. The Tacoma Yacht Club breakwater was built on this material.

The matte was tapped from the low point in the furnace and air blown through it in a converter. Siliceous ore was added which slags off the iron, leaving the blister copper which retains the gold and silver.

After purification in the anode furnace, the molten copper was cast into shapes called anodes. Until 1979 the anodes were placed in the sulfuric acid-copper sulfate baths for electrolytic refining on-site. After 1979 the anodes were shipped by rail to the Amarillo Copper Refinery. Suspended between the anodes were starting sheets of pure copper called cathodes. The electrical current supplied dissolved the copper from the anode and deposited it upon the cathode. The gold and silver, with all but a trace of the other impurity metals, would drop to the bottom of the tanks in the form of black mud or "slimes". The pure copper cathodes were re-melted and cast into commercial shapes. The gold and silver from the slimes were recovered by smelting in a small furnace and capturing the Dore' metal from which the pure silver and gold were extracted.

A sulfuric acid plant began producing acid from the converter off-gases in 1950 and was enlarged in the 1960s. A liquid sulfur dioxide plant began operating in 1974, using an anhydrous dimethylaniline process.

A baghouse was installed to handle dusts from the arsenic kitchen and the metallic arsenic plant in 1977. Arsenic dust collected from the baghouse was combined with arsenic from the kitchen for commercial sale.

A converter slag ventilation system was installed in 1977 in which hoods were used to collect emissions when converter slag was returned to the reverberatory furnace.

A larger baghouse began operating in 1978 to collect particulate matter from the Herreshoff roaster gases. More than 99.9 percent of the particulate matter (by weight) was collected and delivered to the Godfrey roasters in the arsenic plant.

ASARCO's program of reducing air pollution impacts by curtailing operations during adverse meteorological conditions was known as a Meteorological Curtailment Program or a Supplemental Control System (SCS) implemented in 1970. In 1978, data links were established allowing PSAPCA access to the information generated by the SCS. The SCS was expanded in 1979.

The electrolytic refinery ceased operating in January 1979. An anode furnace control system was completed in 1979.

By the late 1970's, all gas streams emitted through the 562-foot main stack first passed through particle collection systems. Gas streams included those from the Herreshoff roasters (after treatment by a baghouse); the reverberatory furnace (after treatment by No. 1 ESP); the Godfrey roasters and arsenic plant (after treatment by the arsenic baghouse); the two sulfuric acid plant residual gas streams which originated at the converter furnaces (after cleaning scrubbers and the cottrells); the anode furnaces (after treatment by No. 1 ESP; and emissions from operations such as slag return to the slag skimming from the reverberatory furnace (after treatment by No. 2 ESP).

In the 1980's additional and replacement emission control devices were installed: the Godfrey Roaster Baghouse was replaced in 1983; converter secondary hooding was installed from 1982-1984; and an enclosed conveying system to convey the Godfrey Roaster calcines was installed in the Herreshoff roasters in 1983.

The copper smelting operations were discontinued in March 1985 due to poor economic conditions and increasing pollution control costs. Arsenic production continued through January 1986. Activity at the site since March 1985 has consisted of: cleanup of materials resulting from the collapse of brick flues on the property and subsequent removal/storage and transport of demolition material; dust removal activities in exit flues, cottrells,

storage silos and the arsenic plant; removal and disposal of PCB containing equipment; dismantling and removal of equipment for re-use elsewhere; and loading arsenic trioxide for shipment.

### 3.2 History of Significant Events and Legal Actions

The history of regulatory activities affecting the ASARCO Tacoma Smelter begins in the late 1960's with the passage of air emission standards by the Puget Sound Air Pollution Control Agency (PSAPCA). Other regulations affecting the plant, such as NPDES requirements, were not applied until 1975, although sampling and analysis of on-site surface waters has occurred over a somewhat longer time period (15 to 20 years). Regulations governing hazardous waste, promulgated by both state and federal agencies, have been used to conduct permitting, monitoring activities, and site inspections, mostly from 1984 to 1986. A summary of significant events and regulatory activity is provided under two headings - Air Quality and Water Quality.

### Air Quality

Rvent

Date

A chronology of air quality-related events affecting the ASARCO Tacoma Smelter is provided below:

Date	Bveirt
03/13/68	Regulation I was adopted by the PSAPCA. Regulation I included enforceable ambient standards for ${\rm SO}_2$ and an ${\rm SO}_2$ stack concentration standard.
07/11/68	PSAPCA issued an order requiring ASARCO to comply with Regulation I standards for SO <sub>2</sub> by July 31, 1968. ASARCO responded to the order by filing a lawsuit seeking, among other things, a declaration that Regulation I was unconstitutional. PSAPCA countersued for a restraining order to prevent further violations.

Late 1968 - PSAPCA staff met with ASARCO staff to determine if a method of compliance could be developed. The lawsuits were held in abeyance during the discussions. The parties were unable to arrive at a successful agreement.

July 1969 PSAPCA demanded compliance with Regulation I and sought to impose civil penalties.

12/29/69 ASARCO applied for a variance from ground-level SO<sub>2</sub> standards until May 1, 1972 in consideration for which it offered to increase the height of its main stack.

03/25/70 PSAPCA denied the requested variance.

08/12/70 After public hearings PSAPCA amended Regulation I SO $_2$  emissions standards to conform to recently passed state standards limiting SO $_2$  emissions to 10% of processed-entry sulfur.

11/10/70 ASARCO applies for a five-year variance from August 12, 1970 amendments offering to construct a new plant utilizing newly available technology for processing converter off-gases to remove almost all sulfur and particulates from converter off-gases by producing liquid SO<sub>2</sub> for commercial sale.

01/13/71 PSAPCA approved a three-year variance to allow ASARCO to install a liquid SO<sub>2</sub> plant to control 51% of SO<sub>2</sub> with option to renew annually until 1975.

ASARCO appealed the three year variance because it had originally sought a five year variance and because of provisions in the three year variance requiring ASARCO to be in total compliance within five years.

- The Pollution Control Hearings Board (PCHB) remanded the three year variance to PSAPCA with the recommendation to amend the variance to allow ASARCO to amortize its investment in the SO<sub>2</sub> plant and to allow ASARCO more time to decide if ASARCO could meet the 90% standard.
- 01/12/72 PSAPCA adopted an amended variance which incorporated the PCHB recommendations.
- Summer-Fall A variety of studies were conducted by PSAPCA, Seattle-King
  1972 County Health Department (SKCHD), Washington State Department
  of Social and Health Studies (DSHS) and ASARCO to determine
  lead and arsenic in soil; lead in blood; and arsenic in hair
  and urine of local residents.
- 11/13/72 DSHS requested adoption of arsenic standards by PSAPCA.
- O1/12/73 PSAPCA requested EPA conduct a total environmental study of ASARCO.
- 03/14/73 Arsenic regulation adopted by PSAPCA.
- 05/73 12/73 A series of studies and sampling efforts were undertaken to determine concentrations of heavy metals and minerals in local pastures, surrounding soil ares, house dust and fugitive emissions from site equipment.
- 12/12/83 PSAPCA granted ASARCO a variance extension to April 30, 1974.
- 05/06/74 PSAPCA granted ASARCO an extension on its variance until June 30, 1974.
- O6/20/74 PSAPCA granted ASARCO an extension on its variance until July 31, 1974.

- O7/31/74 PSAPCA Advisory Council reviewed the smelter impact studies with representatives of ASARCO, EPA, DOE, DSHS, USPHS, Air Quality Coalition and PSAPCA staff. Task Force on Smelter emissions was formed.
- 12/09/74 ASARCO indicated by letter that it would not be able to comply with 90% SO<sub>2</sub> recovery standard by December 31, 1976.
- 04/17/75 A public hearing was held on ASARCO's variance application from §9.03 (visible emissions) and §9.19(c) (visible emissions of arsenic containing particulate) until 1/31/76.
- 05/16/75 PSAPCA denied variance and directed staff to enforce standards.

- O6/25/75 ASARCO commenced a series of appeals to the PCHB seeking relief from PSAPCA enforcement of arsenic emission standard and visual emission standard and seeking reversal of the denial of the variance from arsenic emissions standards.
- O8/14/75 ASARCO petitioned the Pierce County Superior Court for order to show cause why a preliminary injunction should not be issued to prevent PSAPCA from issuing civil penalties with respect to arsenic emissions standards while state PCHB hearing and decision was pending.
- 09/03/75 Pierce County Superior Court issued order restraining PSAPCA from issuing further civil penalties and notices of violation pending PCHB decision.
- 10/31/75 PCHB upheld denial of ASARCO's petition for variance from Regulation I arsenic emission limits.

- 12/05/75 ASARCO filed an application for a variance from  $SO_2$  emission standards (9.07(b) and (c)), visual standard (9.03(b)), and requirement to use best available control technology to limit arsenic emissions (9.19(c)).
- O2/19/76 PSAPCA granted variance to ASARCO for periods ranging from 24 months to five years (December 31, 1980) depending upon the control program proposed by ASARCO and the pollutant involved. Conditions included monitoring of SO<sub>2</sub> and arsenic trioxide emissions and ASARCO support of a urine sampling program among certain children for up to one year.
- O3/18/76 ASARCO offered settlement of civil penalties at issue in appeal scheduled for hearing by PCHB. PSAPCA authorized air pollution control officer to accept the offer.
- 07/76 10/76 Sample results of site testing show no abnormal arsenic levels were found in urine samples from Vashon Island residents.

  Arsenic levels in children living in immediate vicinity of smelter were basically unchanged from levels reported in 1972.
- 03/30/77 PCHB vacated the PSAPCA variance and remanded it to PSAPCA based on a finding that an EIS was necessary.
- 04/05/77 EPA issued a notice of violation to ASARCO for violation of WDOE and PSAPCA emissions standards for SO<sub>2</sub> and particulate.
- 08/12/77 ASARCO filed a new variance application with PSAPCA.
- 12/77 PSAPCA decided that the variance application submitted by ASARCO on 8/12/77 would not be heard until all procedures connected with an EIS were completed.

O1/09/78 Pierce County Superior Court vacated the PCHB order remanding the variance to the PSAPCA board for failure to perform an EIS.

03/24/78 Citizens group appealed the Superior Court decision.

08/09/78 OSHA standard of 10 micrograms/m<sup>3</sup> for arsenic went into effect and was adopted by WISHA.

11/29/78 ASARCO withdrew its August 12, 1977 variance application in anticipation of making new application to supercede the variance of 1976.

01/15/79 ASARCO ceased operation of its electrolytic refiners. WDOE asked EPA to designate ASARCO as an attainment area.

10/11/79 Washington State Supreme Court ruled that an EIS should have been completed before the February, 1976 variance was granted.

Variance application was remanded to PSAPCA until EIS is prepared.

O8/12/80 ASARCO applied for extension to 1976 variance until December 31, 1982.

08/18/80 PSAPCA approved 8/12/80 application.

11/05/80 EPA issued Notice of Violation (NOV) for main stack opacity under Clean Air Act \$113.

1981 Draft and Final EIS issued on amended 1975 variance application. ASARCO was denied variance from opacity granted SO<sub>2</sub> variance subject full regulations but Also, PSAPCA ordered ASARCO compliance by 1987. continuously monitor and report ambient arsenic concentrations.

1982

A study of slag dumping indicated that arsenic emissions from dry slag were less than previously estimated. Further, according to PSAPCA, wet slag dumping produced no arsenic release to the atmosphere. A study of urine samples from children at Ruston Elementary School indicated no significant decrease in arsenic concentrations in spite of lesser smelter emissions.

1983

ASARCO notified PSAPCA of plans for a new  $SO_2$  reducing smelting process, but stated that it would not install a new flue gas desulfurization system.

06/84

ASARCO announced decisions of its Board of Directors to close smelter within one year due to poor economic conditions for copper smelting and high pollution control costs.

March, 1985

ASARCO Tacoma copper smelter closed. Arsenic plant continued operation into January, 1986 to remove arsenic from accumulated flue dust.

### Water Quality

Sampling and chemical analysis of on-site surface waters at the ASARCO facility has occurred intermittently over the past 15-20 years. Such sampling was generally conducted in response to upsets or accidental spills of material at the facility. Regular monitoring at permitted outfalls as part of the NPDES program has been conducted since 1975. Process modifications conducted at the site in 1979 have since resulted in no discharge of process or contact cooling waters to Commencement Bay. Three permitted outfalls currently discharge to the Bay. The North, Middle, and South outfalls discharge stormwater runoff, non-contact cooling water, and surface runoff arising from springs located south and west of the site.

Total loadings of selected heavy metals (i.e., As, Cd, Cu, Pb and Zn) to Commencement Bay from these outfalls were observed to generally decrease during the period 1979 to 1984 (ASARCO 1985). Total loading of these metals during 1984, the last full year of plant operation, was estimated to be 22,049 lbs from the three outfalls.

In the past, upsets or accidental spills of chemicals or contaminants have occurred at the site. Major upsets documented in WDOE files include the following: arsenic flue dust spill of January 7, 1982; sulfuric acid spills of May 24, 1976, June 10, 1983, and July 29, 1983. These accidental spills of contaminants were all followed by cleanup and/or waste removal by ASARCO.

Areas of the site where waste or contaminant materials occur that may enter site runoff waters have been identified (WDOE 1985). These include: Open soils area located north of the cottrell dust storage silos (As); seepage from old arsenic bin (As and Cd); soils located between metallic arsenic bin and the flue (As); area located near old SO<sub>2</sub> off gas flue (As and dimethylaniline (DMA)); area under SO<sub>2</sub> out gas flue from the SO<sub>2</sub> cottrell and soils near the SO<sub>2</sub> plant (DMA and cadmium), and; area near DMA storage tanks (DMA).

In the past, the cooling of slag material occurred at the site shoreline. Molten slag was poured into heavy wooden forms at the water's edge and allowed to cool, forming large slag bulkheads along the waterfront. More recently, molten slag was poured onto the ground surface in thin layers, sprayed with Commencement Bay waters to cool it, and then mechanically broken up and processed. Industrial Mineral Products, Inc. sold the material for sandblasting, riprap, road ballast, and ornamental rock. The aerobic leaching of contaminants from this material has, in the past, been addressed in various studies (Nakatani et al. 1972, 1973; Crecelius 1986) and is considered to be negligible especially after the material has aged.

Prior to closure of the smelter in 1985, airborne particulate emissions from the smelter were subject to dissemination via contact with site surface waters and subsequent transport to receiving waters of Commencement Bay. With plant closure, this mode of surface water contamination has been eliminated.

### 4.0 NATURE AND EXTENT OF THE PROBLEM

# 4.1 Migration Pathways

## 4.1.1 Subsurface

The available geologic and hydrologic data on, and in the vicinity of, the project site indicate that the potential exists for surface contamination to migrate to the water table. Water balance estimates indicate that sufficient precipitation falls on the site to allow groundwater recharge, although much of the precipitation falls on paved areas and is collected before infiltration into the subsurface.

Beneath the ASARCO facility, the available data indicate that groundwater flows toward Commencement Bay. Flow occurs within the uppermost saturated geologic units beneath the southern and western portions of the site adjacent to the regional uplands and within fill materials beneath the portion of the site adjacent to Commencement Bay. Below the water table, contaminants will generally migrate in the direction of groundwater flow. Vertical migration of contaminants into underlying zones beneath the uppermost saturated units is restricted by the relatively low permeability of the underlying deposits and upward hydraulic gradients which likely exist beneath these fine-grained deposits.

### 4.1.2 Surface Water

Surface water runoff pathways for the ASARCO RI study area are, in essence, defined by the stormwater drainage conduits present on site. While some minor diffuse surface water runoff occurs near the property boundary with Commencement Bay, the overwhelming majority of surface runoff is channelized or directed to the existing stormwater drainage system. This drainage system has been identified on a general site level by the Tacoma-Pierce County Health Department in their 1983 report for the Washington Department of Ecology (Tacoma-Pierce County Health Dept. 1983). More specific drainage pathways have been identified from ASARCO storm drainage blueprints (see

Figure 15). These drainage conveyances, in most cases, consist of pipes or conduits constructed for the transport of surface stormwater away from the site. Runoff is generally collected in catch basins, conveyed to the storm drain system, and finally discharged to Commencement Bay via one of three permitted outfalls (see Figure 15).

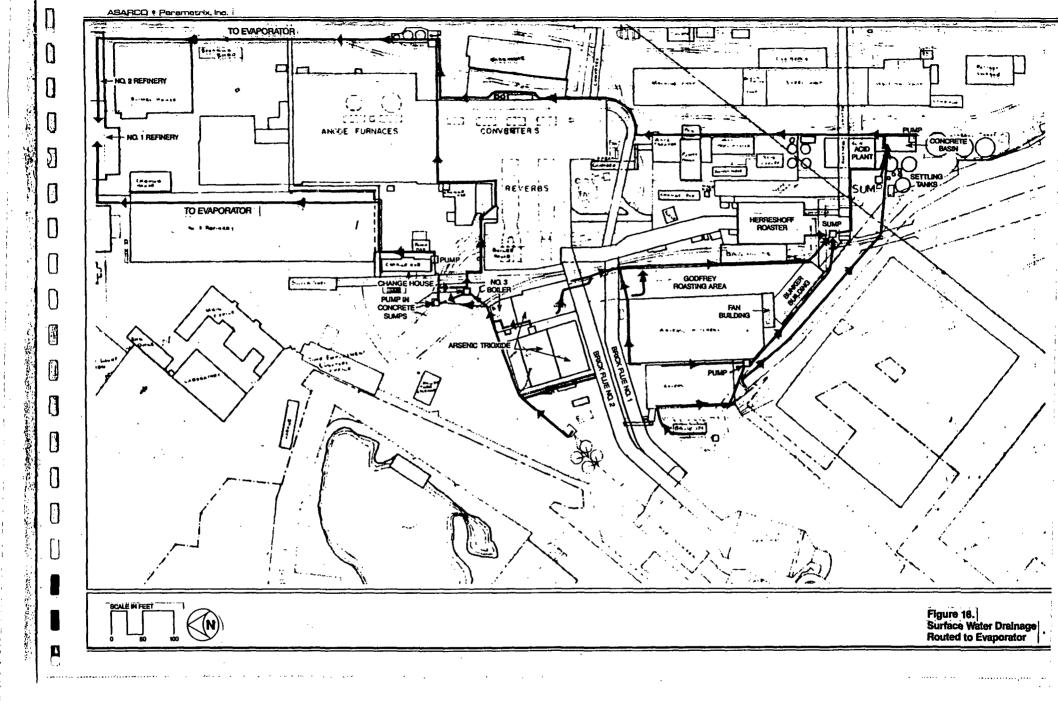
A portion of the on-site surface water drainage is presently being collected and pumped to an evaporator system. This system is presently capable of treating (evaporating) approximately 36,000 gallons per day. Waste sludge is dried and then shipped to ASARCO's East Helena Lead Smelter for processing. Surface water drainage routed to the evaporator is shown in Figure 16.

The integrity of portions of the on-site storm drainage system is in doubt. Drainage flows at the south outfall are always low to non-existent despite the fact that a small stream with an apparent year-round base flow enters the drainage system at a point located approximately 150 meters (500 feet) from the outfall overflow structure. Such observations suggest that surface waters are entering the groundwater via a break in the system. The significance of this is presently unknown.

Because a large portion (50 percent) of the site consists of impervious substrate (i.e., roofs, roadways, and parking lots), permeable surface soils are not present to any large degree. This has significance in terms of groundwater recharge by surface waters which is, therefore, limited by the impervious surface(s) present.

### 4.1.3 Atmospheric

The Tacoma smelter has emitted air contaminants since its construction in the late 1800s. The emissions of primary concern have been sulfur dioxide and particulate matter from the 562-foot main stack and various low level sources, principally the converter-reverberatory building. Substantial reduction in particulate and sulfur dioxide emissions resulted from the installation of control equipment in the 1970s and 1980s.



Because the smelter is no longer operating, it is no longer possible to characterize local air quality based on ambient monitoring data from recent years. The following summary of data collected is offered only to provide an indication of air quality just prior to the shutdown, and does not necessarily reflect current air quality. References to metal concentrations are provided to indicate potential for continued soil contamination on the site.

Although the only long-term high-volume air sampler near the smelter has never recorded a violation of the ambient standard established for total suspended particulate matter, the final decade of smelter operation saw considerable concern over the trace metal contaminants emitted as particulate matter from the smelter. Chemical analysis of stack emissions in 1979 indicated the particulate matter was comprised of 46 percent arsenic, 7 percent lead, and 0.1 percent mercury. Overall, the measurements indicate that the ranking of constituents were (in decreasing order): arsenic, lead, zinc, copper, cadmium, and chromium/mercury (PSAPCA EIS 1980).

Very fine particles are of particular concern because they do not settle out of the atmosphere easily and because they are carried deeper into the human lung.

Since the smelter shutdown in March 1985 and the subsequent closure of the arsenic plant in January 1986, direct process emissions have stopped. Therefore, the large sulfur dioxide emissions which were a major issue during smelter operation are no longer of concern. However, there remains the potential for continued emissions of particulate matter due to clean-up and demolition activity on the site.

ASARCO has monitored the ambient concentrations of arsenic on a daily basis at three locations since 1976. Two of these locations are near the boundary of ASARCO's property, within the plant; the other is located 2100 feet to the southwest. Through 1979, 10 percent of the daily average concentrations exceeded the 2 ug/m<sup>3</sup> standard established later by DOE.

Studies of ambient arsenic concentrations in 1974 and 1977, with and without labor strikes, indicate arsenic concentrations which were 12 and 7 times greater during smelter operation than during shutdowns. Average concentrations in the 1977 study were 0.73  $ug/m^3$  during operation of the smelter and 0.10  $ug/m^3$  during the strike. These concentrations are considerably higher than the 0.002  $ug/m^3$  reported by Walsh et al. (1979) for general continental sites.

Lead has also been monitored near the smelter at the agency-operated monitoring stations at Ruston School, at N. Baltimore St. and at North 26th and Pearl Streets. Quarterly average concentrations have been below the ambient standards since lead monitoring began in 1978. The lead concentration in particulate matter samples collected by ASARCO at its five monitoring sites have been below 1.4 ug/m<sup>3</sup> since 1977.

Table 3. Ambient arsenic concentrations (ug/m<sup>3</sup>). (Highest 24-hour concentration, number of values > DOE standard and annual average)

**************************************				
LOCATION	1983	1984	. 1985	1986*
Maury Island	0.33 (0) .09	0.42 (0) .06	0.16 (0) .02	0.02 (0) na
Ruston School	1.60 (0) .45	2.40 (1) .32	6.89 (7) .77	1.00 (0) na
N. Baltimore St.	4.01 (5) .45	3.26 (4) .37	5.16 (6) .49	1.14 (0) na
26th and Pearl	1.00 (0) .11	1.10 (0) .13	1.39 (0) .09	
Dupont	0.13 (0) .01	1.68 (0) .05	0.08 (0) .01	

\* First six months only

Source: PSAPCA annual air quality data summaries

Although the smelter and arsenic plant are no longer operating, on-site clean-up and wind may re-suspend particulate matter from the site and carry it off-site. A number of studies indicate significant concentrations of contaminants in the soil on- and off-site.

Atmospheric transport of particulate matter from the site is a potential pathway for continued community exposure. Sources include residual process materials, contaminated soil on the site, and dust layers on the surfaces of buildings and other structures. The potential for re-suspension depends on the size distribution and moisture content of the particulate matter, whether it is aggregated or "glued" to other material, wind strength, and other factors.

If the particulate matter from the site is resuspended and carried off-site by winds, people can be exposed by breathing or ingesting particulate matter. Factors affecting the impact of an exposure include the concentration of suspended particulate matter, its chemistry and size distribution, the duration of the exposure, and the sensitivity of the individual or population.

## 4.1.4 Aquatic and Biological Resources

Possible pathways for migration of contaminants from the ASARCO site to the marine environment are currently from groundwater flow and surface water runoff. During plant operation, slag dumping, and spills of raw ore from barges during off-loading at the ore dock were also potential migration pathways.

Surface water runoff throughout the ASARCO site is routed to several outfalls that empty directly into Commencement Bay. Contaminants, primarily heavy metals, come in contact with rainwater and are washed from the smelter site into the marine environment. Upon reaching Commencement Bay, contaminants are dispersed via current and tidal action. Effects of contamination on the marine environment are dependent upon concentration and residence time in the discharge area.

The dumping of slag into Commencement Bay which ceased January 1, 1983, allowed direct contact of contaminants with the marine environment. Contaminants most likely were released at a relatively high rate from molten slag, and more slowly from the slag as it cooled and hardened. Slag dumping could have greatly elevated contaminant levels in Commencement Bay during the actual dumping of molten slag, as well as elevated background contaminant levels from leaching of cooled, hardened slag. Disintegration of slag by wave action may contribute to particulate slag contamination of adjacent marine sediments.

Contamination of Commencement Bay could also have occurred from ore spills during barge off-loading at the unloading docks. Contaminants could leach from raw copper ore similar to the leaching from cooled slag. Significant ore spills could have a greater effect on the marine environment than slag leaching due to higher concentrations of contaminants in raw ore than in the refined slag.

## 4.2 Receptors

The ASARCO-Tacoma smelter is located in an area including industrial, residential, and recreational land use. Human receptors may be exposed to contaminants originating from the site through pathways including air, groundwater, surface waters, soils and dusts, and ingestion of contaminated plants and animals.

Previous studies have found elevated concentrations of arsenic in the soil, air, and other environmental media in the communities surrounding the ASARCO-Tacoma smelter. Elevated concentrations of arsenic have been found in urine and hair samples collected from children living near the smelter. For these reasons, attention has been focused on potential human receptor populations and related health impacts.

Recent estimates of human exposure to arsenic have been provided in the Ruston/Vashon Island Arsenic Exposure Pathways Study conducted by the

University of Washington. This study included simultaneous collection of biological samples (urine, hair) and environmental samples (air, soil, house dust, handwash rinsate, drinking water, garden vegetables). Results released in Preliminary Final Major Findings of the Study indicated that both environmental and biological arsenic values are highest closest to the smelter and decrease with increasing distance from the smelter. Available data indicates that groundwater beneath the site is a potential receptor of contamination originating on the site. However, no drinking water aquifer or wells are present on or downgradient at the site.

However, urinary arsenic concentrations were not well predicted by measured environmental concentrations. Males under age six appeared to have the highest daily intake of arsenic and the highest hair arsenic concentrations.

Major findings indicated that the majority of the study population had urinary arsenic concentrations comparable to other areas without arsenic emitting sources, arsenic concentrations in drinking water were far below state and federal standards and are comparable to concentrations in other areas of Puget Sound and that concentrations of inorganic arsenic in vegetables were within the range reported for uncontaminated vegetables in previous studies.

Human and environmental impacts (i.e., flora and fauna) have been described previously in the Draft Environmental Impact Statement for ASARCO, Inc. Application for variance from PSAPCA Regulation I, Sections 9.03(b), 9.07(b) and 9.07(c).

### 4.3 Potential Impacts

### 4.3.1 Groundwater

Relatively high concentrations of arsenic, antimony, copper, lead, and zinc have been detected in shallow groundwater beneath the site. Possible impacts to Commencement Bay may exist from discharge of contaminated groundwater to the Bay.

## 4.3.2 Surface Water

The transport of contaminants via surface waters from and/or through the ASARCO site poses a potential impact to biota present in the receiving waters of Commencement Bay. Due to the physical presence of buildings, roads, parking lots, and other man-made structures, the majority of the site presently supports little or no terrestrial biota associated with surface waters. Therefore, potential impacts associated with surface waters of the site may be said to arise from stormwater runoff and the subsequent discharge or loading of site contaminants to Commencement Bay. Existing impacts to adjacent marine biota and those contaminants of concern have been recently identified by the Commencement Bay Nearshore/Tideflats RI (WDOE 1985).

The source(s) of those contaminants carried by site surface waters most likely includes wastes present on-site which have not yet been characterized. Movement of these wastes through direct precipitation, (i.e., runoff via sediment transport or solute transport) may presently be considered to be the primary mode of contaminant transport via site surface waters. (Solute transport or leaching of soluble contaminants may also occur due to the movement of groundwaters).

### 4.3.3 Air Quality

Monitoring data from PSAPCA indicate there have been no violations of ambient standards for criteria pollutants since the plant ceased smelting in March 1985. There have been a number of occasions where arsenic concentrations have exceeded DOE's 24-hour standard of 2 ug/m<sup>3</sup>, however. These exceedances have been related to cleanup and arsenic trioxide loading activities subsequent to closure.

Most of the heavily contaminated structures, including the brick flues and arsenic plant, will soon be removed from the site as part of a demolition plan approved by EPA. Nonetheless, surface dust and contaminated soil may still be disturbed and resuspended by on-site activity or wind, and it is this potential source which needs to be investigated.

Midwest Research Institute (MRI) collected surface soil samples and evaluated their susceptibility to wind erosion and resuspension by mechanical disturbances (MRI 1983). MRI noted that wind erosion would be minimal during Puget Sound's wet winters and that threshold wind speeds for wind erosion occur less frequently during the drier seasons.

MRI also noted that material which showed a substantial tendency to form a crust, such as cottrell dust, are resuspended at higher rates when disturbed. MRI concluded that resuspension of surface soils by wind erosion would be minimal compared with potential emissions due to mechanical soil disturbances by vehicles or other human activity.

The primary concern is that fine particles, which tend to be more enriched in metallic contaminants than coarse soil particles, are also more easily resuspended. Furthermore, fine particles penetrate deeper into the lung, and are retained longer than larger particles.

## 4.3.4 Aquatic and Biologic Resources

The greatest impact to the marine environment from smelter contamination could be alteration of the benthic community structure. Species intolerant of contamination might be eliminated from the population, allowing more tolerable species to flourish. A worst case scenario would be elimination of the entire benthic community. Alteration or elimination of the benthic community, which is near the base of the aquatic food web, could cause alteration of the entire marine community near the smelter. Fish and shellfish could experience a serious reduction in numbers or create a health hazard to humans from bioaccumulation of contaminants.

#### 5.0 SITE BOUNDARY

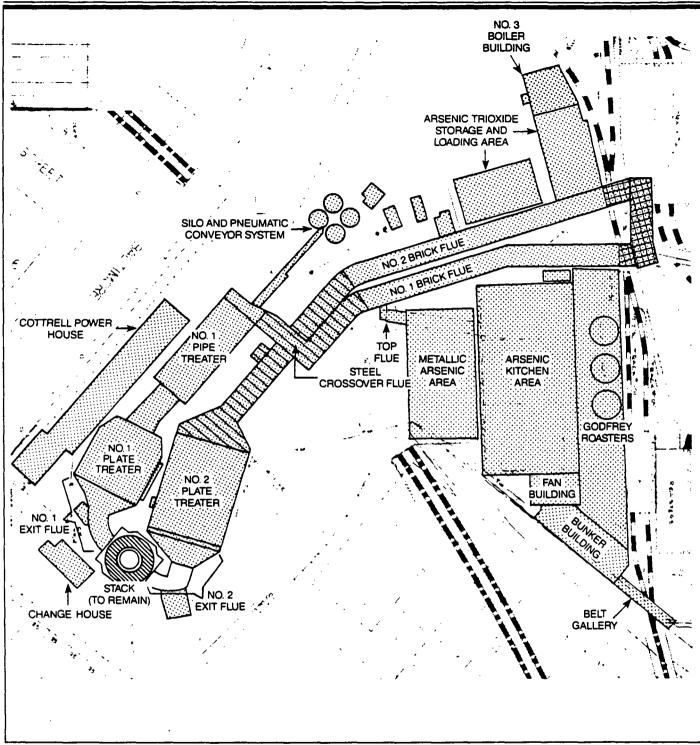
The boundaries established for this remedial investigation were determined with consideration of the actual property boundary of the ASARCO facility, nearby slag fill areas, the geographical limits to be covered by the RI planned for potential ASARCO-related off-site impacts, and delineation of off-shore areas which may have been directly impacted by plant activities. The purpose of establishing site boundaries is to limit the areas of site investigations while allowing for coverage of a sufficiently detailed area to support the feasibility study. Therefore, the site boundaries include all the Tacoma plant property and adjacent shoreline to water depths of approximately 200 feet off-shore (see Figure 2). Pending agreement with the Tacoma Metropolitan Park Board, the site boundary will also include the slag fill area owned by them and used as a breakwater for the Tacoma Yacht Club. This RI will not address remedial action alternatives dealing with sites outside the ASARCO property boundary.

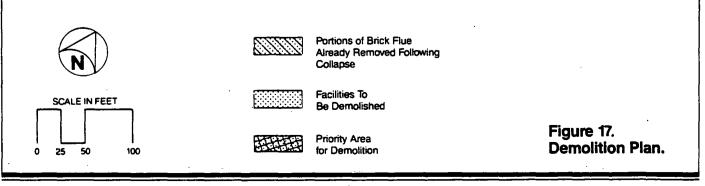
### 6.0 INITIAL REMEDIAL MEASURES

Site stabilization activities at the ASARCO Tacoma smelter have been planned and incorporated into the Consent Order negotiated between ASARCO and EPA (EPA Docket No. 1086-04-24-106). These site stabilization efforts are considered Initial Remedial Measures (IRMs) because they are remedial actions to be implemented before final selection of appropriate remedial actions. The rationale for performing clean-up activities early in the RI/FS process is to further limit potential arsenic fugitive dust emissions.

The IRM will include demolition of various facilities that were associated with copper smelting and the production of arsenic trioxide and metallic arsenic. Due to the accumulation of arsenical dust in these facilities over the years, and the potential for deterioration of the structures with further aging, they are considered to pose a greater environmental risk than other facilities on-site. Structures to be demolished are shown on Figure 17, and include:

- 1. Cottrells (electrostatic precipitators), including the No. 1 pipe treater and No. 1 and No. 2 plate treaters.
- 2. Cottrell powerhouse and changehouse.
- 3. The remaining portions of No. 1 and No. 2 brick flues. Priority in demolition will be given to the area of the flues shown in Figure 17.
- 4. Silo and pneumatic conveyor system.
- 5. Arsenic plant, including the roof and supporting structures, the metallic arsenic area, the Godfrey roasters, the arsenic kitchens, the fan building, the bunker building, the arsenic trioxide storage bins and the #3 boiler building.





Specific procedures and environmental controls which will or have been implemented as part of site stabilization are discussed in detail in Attachment A to the Administrative Order on Consent, EPA Docket No. 1086-04-24-106, negotiated between ASARCO and EPA. A brief overview of the planned cleanup activities is provided below.

The major items of preliminary cleanup activities are: dust removal from various structures, cleanup of collapsed brick flues, removal of asbestos, removal of reusable equipment and disconnection of utilities.

## Dust Removal

<u>Brick Flues</u>. Dust in the No. 1 and No. 2 brick flues was removed by pulling the dust from the flues with a scraper to railroad gondola cars located in a passageway between the arsenic plant and the waste heat boiler areas. Flue pulling was not completed due to the unexpected collapse of a portion of the flues. The remaining flue dust will be removed during demolition.

Exit Flues. Dust in the exit flues from No. 1 and No. 2 plate treaters, as well as dust at the base of the stack, was removed using small front end loaders and hand shovels. Dust in the No. 2 exit flue was removed and handled in a similar fashion. Following demolition of the No. 1 exit flue, the opening at the base of the stack from this flue will be permanently sealed.

<u>Cottrell Hoppers and Dust Conveying Systems</u>. Collection hoppers and dust conveying systems located in the basement of each treater building were used for collection of dust from the Cottrell electrostatic precipitators and transference to storage silos. These structures were emptied and cleaned as part of the preliminary cleanup work.

<u>Cottrell Buildings</u>. Dust removal efforts in all three Cottrell buildings included removal of remaining dust in the treaters by using plant air to blow dust into collection hoppers in an enclosed screw conveying system. Settled dust was also cleaned from the floors and walkways in the area.

<u>Storage Silos</u>. The four storage silos and associated dust conveying systems were emptied. To ensure complete evacuation, all hoppers, including pressure pots, were opened and inspected.

<u>Arsenic Plant</u>. Except for the arsenic trioxide loading area, all accessible structures in the arsenic plant area, including roofs, beams, cross members, and floors, have been vacuumed. The arsenic trioxide loading area will be cleaned once its use is discontinued.

Cleanup of Collapsed Brick Flues. During the summer of 1985, after copper smelting operations had ceased at the ASARCO plant, a portion of No. 1 and No. 2 brick flues collapsed (see Figure 17). It is possible that the deteriorating structures were weakened further by the flue pulling conducted in preparation for demolition. The collapse resulted in a pile of rubble, consisting primarily of brick, but also containing concrete, steel, wood and flue dust mixed with soil. Several walls and a steel crossover flue immediately adjacent to the collapsed flue sections were also in danger of collapse.

Following the collapse, ASARCO took a number of steps to ensure the safety of employees working in the collapse area and to prevent dispersion of flue dust by wind or surface water runoff. With the permission of the Town of Ruston, unstable structures adjacent to the flue sections, including the steel crossover flue, were removed. All rubble was removed using front end loaders and dump trucks. The material was transported to either the fine ore bins or a converter aisle located on plant property for temporary storage until it could be analyzed for toxicity and a method of disposal determined. The storage areas were covered and protected so the materials were not subject to surface water runoff or wind dispersion.

After clean-up, the collapse area was graded, with approximately the top three feet of soil removed and added to rubble stored at the plant. The entire area of collapse was then covered with heavy plastic material, which was securely anchored, to ensure that rainfall and subsequent surface water runoff would not come into contact with the exposed area. This plastic cover will be maintained until the demolition of adjacent structures begins.

Based on an analysis of brick rubble using the Extraction Procedure (EP) Toxicity Test, the rubble in temporary storage was designated as dangerous waste due to concentrations of arsenic and cadmium. After a contract was executed with Chem-Security Systems, the material was transported to its fully permitted hazardous waste disposal site in Arlington, Oregon. It is estimated that approximately 2,200 tons of this material was removed from the site.

Because the flue collapse occurred before all flue dust could be removed from the brick flue system, some flue dust still remains. Due to the structural instability of the remaining flues, it is not possible to conduct any further cleaning. Therefore, this dust will have to be removed at the time of demolition.

Asbestos Removal. Asbestos-bearing materials such as wall and pipe insulation will be removed from buildings prior to demolition in areas where EPA's and ASARCO's OSC agree that such removal is practicable. ASARCO has identified areas where insulation is known to be present, and has determined by laboratory analysis, where necessary, whether the material contains asbestos fibers.

Reusable Equipment. Reusable items of equipment in the structures to be demolished will be removed and retained in storage for subsequent sale or for use in another ASARCO facility. This includes certain electrical transformers, motor control center equipment, stack heater equipment, instrumentation, etc.

<u>Disconnection of Utilities</u>. The following steps have been taken or are planned to disconnect utilities prior to demolition:

- All D.C. power was turned off at the transformers after completion of flue pulling and other clean-up activities. Before demolition, all electrical switchgear and equipment will be removed.
- 2. The natural gas lines were purged and certain water lines drained. To accomplish this, air was introduced at the main headers and branches at the ends of the lines were opened. Water will remain in some areas to aid in dust control.
- 3. Air lines were disconnected except those that will be needed in some areas during demolition and cleanup.

Removal of PCB Equipment. As of May 1, 1986, all equipment containing polychlorinated biphenyls (PCB) has been removed from the site and disposed of in accordance with EPA regulations. There is no PCB-containing equipment on-site at this time

#### 7.0 POTENTIAL GENERAL RESPONSE ACTIONS

Five alternative categories of remedial action are considered for further refinement into general response action alternatives. Before serious consideration of viable remedial strategies can occur, remedial action data needs must be identified and addressed from site specific remedial action alternatives. Five (5) performance categories of remedial action have been identified:

- 1. Off-site disposal of contaminated site materials
- Alternative technologies that achieve public health and environmental standards
- 3. Alternative technologies that do not achieve public health and environmental standards
- 4. Alternatives which do not achieve public health or environmental standards, but will reduce the likelihood of present or future threat from hazardous substances
- 5. No action

Within the first four categories is a universe of potential engineering alternatives. The selection of various technologies will depend upon the effectiveness of the technology and the degree of cleanup required. This degree of cleanup, or cleanup standard will be based on Agency consideration of migration pathways and identification of receptors.

Some technologies which appear to be common to Alternatives 1 through 4 are:

- 1. Soil removal; partial or complete
- 2. On-site disposal
- 3. Off-site disposal: demolition landfill, sanitary landfill, RCRA facility
- 4. Groundwater pumping: with treatment, without treatment
- 5. Containment: capping

6. Collection: sedimentation basin, french drains, gas collection system to control emissions

From these general response actions and associated remedial technologies, further media specific alternatives can be derived which include:

- 1. Air Pollution Controls: capping
- 2. Surface Water Controls: capping, grading, revegetation, diversion and collection
- Leachate and Groundwater Controls: capping, groundwater pumping,
   collection drains
- 4. Radon Migration Controls: capping, active gas collection systems
- 5. Excavation of Soils and Waste: excavation, grading, capping, revegetation
- 6. Removal of Contaminated Sediment: sediment removal, sediment turbidity control
- 7. In-situ Treatment: oxidation
- 8. Direct Waste Treatment: incineration, gaseous waste treatment

The previous options will be considered in combination in order to produce optimum results. Numerous site specific parameters will affect the ultimate remedial action. These parameters include: site area and volume; site geometry; soil texture; permeability moisture; site topography and relief; drainage and vegetation; site geology including boundary conditions of groundwater flow; groundwater velocities; and the rate and extent of existing contamination. Furthermore, the nature of contamination will have a tremendous influence on the selection of remedial action alternatives.

Of particular importance are the mass and volume of contaminants present, the chemistry of the contaminants which influences toxicity and environmental migration, and the treatability of the particular contaminants.

#### 8.0 DATA NREDS

#### 8.1 Waste Characterization

The objective of this effort is the regulatory characterization of certain site specific waste materials. These materials will be identified during the course of the remedial investigation and embrace the universe of potential site derived media. Those materials identified for waste disposal will be managed according to the appropriate techniques described in the Resource Recovery and Conservation Act (RCRA) or the Washington Administrative Code (WAC-173-303) for Dangerous Wastes.

In order to assure compliance with the appropriate regulations, materials will be sampled and analyzed to determine whether or not they are hazardous. Guidance for such sampling and analysis are contained in SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, July 1982 (Update I, 4/84; Update II, 3/85), U.S. Environmental Protection Agency, Office of Solid Waste and Energy Response.

Material tested for regulatory compliance will be handled and managed accordingly. It is anticipated that the multi-media waste stream generated by this remedial investigation will require thorough characterization, and the existing environmental data bases associated with ASARCO can not address waste characterization for regulatory compliance purposes.

#### 8.2 Groundwater

Sufficient geologic data exist to assess the regional and general site geologic conditions. However, the northern one-third of the site appears to be underlain by a different geologic sequence as compared with the remainder of the site. The geologic sequence beneath the northern third of the site needs to be further defined.

Three fill types have been identified to exist beneath the site. The distribution, thicknesses, composition and extent of these fills should be further defined.

Limited hydrogeologic information exists for the site. While the available data indicate groundwater flows toward Commencement Bay, additional data should be collected to support this finding. The interaction of groundwaters with Commencement Bay, groundwater quality conditions and loadings to the Bay via groundwater transport should be further assessed.

### 8.3 Surface Water

Data are lacking with which to determine contaminants present in surface waters entering and present on the ASARCO RI site. While data has been collected and is presently being collected from the three permitted outfalls, this information gives no indication as to the upstream source of contaminants. In at least one case, outfall discharge appears unrelated to upstream stormwater conduit flow (i.e., the South Outfall). Because most of the site surface waters have not been characterized, the potential impacts to receptors, including humans, have yet to be fully evaluated.

Stormwater discharge and loading of contaminants to Commencement Bay receiving waters have not been evaluated for at least two of the three outfalls. The North and Middle Outfalls are sampled once daily for a weekly composite sample, thus storm event characterization of these discharges does not exist.

The significance and contribution of seeps and springs present in the study area have not been evaluated.

#### 8.4 Soils

Soil data gaps and uncertainties exist at the ASARCO facility, and must be filled and/or resolved in order to "identify threats to human health, welfare or the environment..." and "to identify and evaluate remedial actions which

will mitigate these threats." The identified data gaps consist of areal distribution of contaminants, vertical contaminant distribution, average contaminant values for specific soil types, and representative soil particle size distributions.

Soil conditions at the ASARCO facility are highly anisotropic with respect to both physical and chemical properties. Anisotrophy is the result of directional variations that have resulted from natural and artificial depositional events, materials-handling practices and historical site activities. In spite of these variations, two regions of similarity in soil conditions can be identified: site areas underlain by natural soils, and areas of extensive fill. Soils must be evaluated in these regions to establish certain intrinsic properties such as particle size distribution, which are of significance in determining the impact of this site on the environment by airborne transport of fugitive dust and their respective chemistries.

From an environmental standpoint, this site may represent a loading source for various metals and certain organisms into the environment. Therefore, it is essential that average values of contaminant concentration be established for these soils. Such averaged values will be used to estimate leaching potential as well as assessing the potential airborne impact of site soils.

## 8.5 Air Quality

A number of tasks remain before a satisfactory evaluation of the site can be conducted. The first task is to evaluate existing monitoring and meteorological data. TRC has obtained magnetic tapes of suspended particulate matter data (and chemistry) from ASARCO's sampling network and almost five years of meteorological data from the Tavern site. Data from these tapes are being downloaded to floppy disks for analysis during Task 3-Site Investigations.

Size-segregated chemical data for on-site particulate matter are needed. As noted above, a number of previous studies have reported, to various degrees

of detail, concentrations of contaminants in surface soils on and off-site. These studies were conducted during smelter operation, and may not be representative of current conditions. The resuspension of soils currently present on the site may produce significantly different aerosols than have been measured in the past. Studies near a now-closed lead smelter in Kellogg, Idaho, for example, showed that the lead concentration in suspended particulate matter had a half-life of 4 to 5 months (Cooper 1986).

The air quality models to be used during the feasibility study consider the size distribution of particulate matter when determining the concentration at a distance from the source. TRC recommends extending the sizing techniques planned for the soils analysis to focus on particles smaller than 30 microns, which are the particles most easily resuspended and carried for significant distances. Analysis of metal concentrations, especially arsenic, in several size classes less than 30 microns, are recommended.

A final task to be completed during the remedial investigation is a more careful evaluation of sensitive receptors near the site. These receptors will be used in the modeling study to evaluate the impacts of resuspended particulate matter from the site.

### 8.6 Aquatic and Biological Resources

Determination of contamination effects, if any, from the ASARCO smelter requires data be collected that describe the extent of areal and depth distribution contamination and the associated distribution of marine benthos.

An initial examination of surficial sediment contamination, over a broad area, will determine the areal extent of any contamination and concentration gradients of contaminants. Core sampling for contamination depth distribution, and van Veen grab sampling for biological contamination effects, will both be dependent upon the results of the surficial sediment chemistry analysis for the location of sampling stations. Analysis of data obtained from core sampling and biological sampling will determine the depth

distribution of contaminants in the sediment and contaminant effects on marine biota inhabiting the sediment.

### 8.7 Receptor Identification

Relevant information on levels of contaminants and potential pathways for contaminant migration should be generated from the results of the Sampling and Analysis Plans describing on-site waste materials, groundwater, surface water, soils, air, and aquatic and biologic resources. Other pertinent information required to perform the receptor investigation include the following:

- o Current uses of groundwater (residential, municipal, industrial wells) potentially transporting site contaminants
- o Current uses of surface water and site runoff water
- o Estimates of human exposure to contaminants via ingestion of contaminated fish and shellfish
- o Estimates of long-term impacts to local flora and fauna

Information regarding special plant species and communities in the site vicinity will be obtained from the Washington Department of Natural Resources Natural Heritage Program. Similar information regarding endangered, threatened, or sensitive animal species will be obtained from the Washington Department of Game Nongame Program.

### 8.8 Slag Leaching and Radon Emissions

Laboratory studies have been completed on the metal leaching properties of ASARCO slag. Limited field data exist to evaluate how the laboratory results represent field conditions. Additional data are needed to assess how accurately the laboratory conditions and test results represent field conditions.

Since much of the facility consists of fill, which is smelter slag, the impact of this material on the environment must be addressed during the remedial investigation. To accomplish this, samples of leachate will be collected, analyzed for contaminants of concern, and the results compared to concentrations of contaminants determined to be present in the slag. Since leaching is a function of both contaminant of concern and the porosity and permeability of the slag, preliminary estimates of slag porosity and permeability will also be considered in evaluating the potential for slag leaching.

Monitoring for Radium 226 will occur as elements of the groundwater, soil and slag investigations. A specialized Radon monitoring program will be included as an element of the slag leaching investigation. Concern regarding these elements and their potential at this site has been raised by the regulatory community. While it is not believed that the activities which occurred at ASARCO have had significant potential for concentration of these elements in slag, the testing carried out during this effort should answer such concerns.

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